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PROCEEDINGS

OF THE

Boston Society of Natural History.

VOL. XXIII.

WITH EIGHT PLATES

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1888.

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PROCEEDINGS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY.

TAKEN FROM THE SOCIETY'S RECORDS.

General Meeting, January 2, 1884.

Ex-President, Mr. T. T. Bouvé, in the chair. Thirty-seven persons present.

The following members were elected: to Honorary Membership: Dr. William B. Carpenter, of London. To Corresponding Membership: Prof. Ferdinand Cohn, Breslau; Prof. F. Fouqué, Prof. A. M. Lévy, and Prof. E. J. Marey, of Paris; Dr. Paul Mayer, Naples; Prof. A. R. C. Selwyn, Ottawa; and Dr. Augnst Weismann, Freiburg. To Corporate Membership: Miss Cora H. Clarke, Dr. H. E. Davidson, Miss M. H. Hinckley, Mr. J. S. Kingsley, Mrs. R. H. Richards, and Mrs. C. O. Whitman. To Associate Membership: Mr. George H. Barton, Prof. B. K. Emerson, Prof. W. T. Sedgwick, Mr. G. S. Miller, Jr., Miss Mary T. Palmer, and Mr. R. P. Williams.

The following paper was read: —

NOTES ON GEMS.

BY THOMAS T. BOUVÉ.

Some experience in the examination and identification of gems within the past year or two leads me to write a few notes upon some of them, believing that what I may communicate will interest many and possibly give information that may prove serviceable.

It was not until quite recently that any deep green stones were in general use as jewels, which could be at all compared in beauty with the Emerald. To-day we have two others, the Hiddenite and the Garnet, and it is not easy to decide which of the three is the most beautiful. Of the Hiddenite a full account has been given in the American Journal of Science, third series, vol. 21, p. 128, and vol. 22, p. 179; and it is, therefore, unnecessary to say more respecting it, but a few words will be added below suggestive of the modes of distinguishing it from the others. The Garnet, in its red shades, has from remote ages vied with the Emerald in exciting admiration, but had never until within two years appeared before the world as a jewel in the brilliant green hue which now makes it an object of so much attraction. The first stones seen in this country were received by Dr. Leidy, of Philadelphia, and were presented to him by a friend abroad as gems he would highly prize for their unique character. They were called Garnets, and he verified them to be so to his entire satisfaction. Not long after some of the same were received in Boston from a dealer in London under the name of green Hyacinths. There was much doubt respecting their character, nothing having then been learned here of those received by Dr. Leidy. Subsequently, however, when it was known that stones unquestionably identical were in his possession which he had decided to be Garnets, they became recognized as such. Singularly, however, their true character was again doubted upon optical grounds, as it was thought from imperfect examination that the crystalline structure was not isometric. To convince myself respecting them I broke a small stone in fragments and subjected a particle to blowpipe action. It melted readily and a small, black bead was produced which was magnetic, thus satisfactorily showing, with other evidence, that the mineral was no other than Garnet containing considerable iron. From further information it was learned that many stones had been received from Siberia and cut in London, and they soon became common in our markets. They are readily distinguished from the Emerald by greater brilliancy and by yellowish reflections. The color is generally not so dark and is nearly grass-green in shade. These remarks apply to the greater portion of them; there are some, however, of a decidedly less bright green tint, the color being rather more olive. From properly cut stones of both hues, there are perceived, when favorably held, blueish and reddish reflections such as are seen in Diamonds but never in Emeralds or Hiddenites.

The Hiddenite is also distinguished from the Emerald by its less dark shade, and often too by greater brilliancy. From the green Garnet it generally differs in lacking the yellowish tint in its reflections, though in rare instances something of this is perceived. The yellow shade is, however, never so marked a feature as in the Garnet. Of course comparison should be made by day as by artificial light the yellow reflections are not perceptible in either gem.

One might infer from the statement made of the greater brilliancy of both the Hiddenite and the Garnet, when compared with the Emerald, that this should decide their relative beauty; but that is not the case, for the Emerald has a beauty of its own in its deep and rich shade of color, that will ever make it rank at least an equal in loveliness with the newer aspirants for favor.

Another gem has been received by the dealers within a short time, the character of which, so far as I can learn, has not been understood either here or abroad. Several years ago I bought from a leading house in Boston two beautiful light yellow stones said to be Chrysolites, and had them set as pendants. Their shade of color was quite like that of the yellow Diamonds now so frequently seen, and indeed they were when worn mistaken for them by the inexperienced. A few months since similar stones were bought in London, the dealer acknowledging his ignorance of their character. One of these came into my hands and finding it to have the specific gravity of Spodumene, about 3.18, I was led to weigh those also which I had bought and had set as Chrysolites. As suspected, their specific gravity indicated that they were of the same composition.

To make assurance doubly sure respecting their true character, I scraped off from the girdle of one of them, sufficient quantity of powder for examination. This was mixed with fluorite and bi-sulphate of potash, in the proportions suggested by Professor Dana in his System of Mineralogy, made into a paste and subjected to blowpipe action with the expected result of producing a beautiful lithia red flame. Thus it was shown that we have among gems, not only one representative of the mineral Spodumene in the green variety Hiddenite, but a second of a light yellow or yellowish white color. This last is supposed to come from Brazil, though as yet I have no positive information on the subject.[1]

The lack of knowledge on the part of jewelers and dealers in precious stones, as to the specific character of those which pass through their hands and the modes of determining this, has been a matter of great surprise to me considering especially that they have been constantly liable to receive, as well as to dispose of, inferior gems for those of superior value. True, they become expert in detecting the one from the other by the eye alone, and in case of stones not set, the hardness is somewhat relied upon. But who can tell without resort to other means many of the Chrysoberyls from Sapphires, or some of the Zircons from Topazes and Garnets. How many will venture to decide from four white cut stones which is a Topaz, which a Sapphire, which a Phenacite, and which a Beryl. If it is said that the hardness is different and should distinguish them, I will reply that though this might be true with freedom of manipulation and proper means of comparison, that ordinarily it would not be found easy to show the degrees of hardness. Indeed, without considerable experience and judgment, even with freedom of manipulation and proper appliances there is likely to be error.

To prove to me that a stone was a Beryl, the edge of it was shown to scratch readily the face of a Quartz crystal, but when I asked the dealer to try fairly the edge of another quartz stone on the same face he was obliged to admit that he quite as easily produced as much effect.

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[1] Since the above was written stones of the character mentioned have become more common. They are brought from Brazil.

Gems from the mineral Andalusite have also appeared. They are of a light olive tint, but exhibit from remarkable dichroism a beautiful orange hue in the sloping step facets. Through a dichroscope the twin colors are a light olive and a deep red. These also are said to come from Brazil.

Stones are every day bought of dealers for what they are not, and this, too, is done without any intention on their part to deceive. I take the opportunity to here state that with an intimate knowledge respecting many in our large cities I feel sure that they are generally men of highly honorable character, who would despise using deception in their business transactions.

Of course buying as they do the cut stones from abroad and relying mainly upon the eye alone to distinguish one gem from another, it is absolutely impossible for the most experienced of them not to be sometimes deceived.

That the discrimination of the degrees of hardness among gems is not very accurate, even with lapidaries, may be judged by the fact, that having some rough Ceylon stones, I sent seven to one well-known lapidist asking that he would give the name to each as determined by him in cutting them. All but two were pronounced Sapphires. I subsequently proved that there was but one Sapphire among them all and that four so-called were Zircons. This was demonstrated both by their specific gravity, and by dissolving the powder fused with soda in muriatic acid and obtaining upon immersion of tumeric paper the beautiful orange tint which only Zirconia yields.

Before concluding I will state what may be of importance to those who incline to test gems for their specific gravity, that they will not find any such variation as is given in the mineralogical works for the species to which they respectively belong. This, of course, might be expected as the range of weight thus given is not always confined to the purest crystallized mineral. Take Quartz, for instance, the specific gravity is stated as from 2.5 to 2.8. Now there is no such variation with this mineral as it presents itself in transparent gems. In truth, the variation is surprisingly small. Examining as I have done a very large number of stones, I am led to the belief that there is seldom if ever any that vary two hundredths of a millegram from 2.65. In all my weighing I have found but one specimen that fell below 2.64, and this but three thousandths of a millegram; and only one that exceeded 2.66, and this but eight thousandths of a millegram. The stones weighed included all the varieties of the crystallized mineral, the white, the yellow of different shades, the smoky, and the Amethyst. Now to appreciate the importance of such a presentation it is only necessary to show that by a like accurate one given of the Beryls used in jewelry it is possible to distinguish the one species from the other by weight, which cannot be done if it is assumed that the variation of the specific gravity is as given in the mineralogical works; for if Quartz is taken to have a range of from 2.5 to 2.8 and Beryl 2.6 to 2.74, there is, of course, no distinguishing them by this means. If, on the contrary, the heaviest of the Quartz stones never have the specific gravity of the lightest Beryl, the discrimination is easy. This I feel quite sure is the case, though of course I am unwilling to state that there will not be found stones that may prove exceptional. I have weighed too many, however, not to have full faith in the conclusion I draw from my figures; namely, that Quartz gems never weigh 2.67 and that Beryls including the Emerald, the aqua marine, and the yellow and white varieties which have a varying specific gravity of from 2.684 to 2.74 never fall below the former figures, whilst the greater number weigh over 2.7. Thus though the limits of variation approach each other, they yet seem to be clearly distinct. The cases, indeed, are exceedingly exceptional where the divergence is not greater, only, as stated, two instances being noticed in a multitude of examinations.

Dr. S. Kneeland read a paper, illustrated by the stereopticon, on the subsidence theory of earthquakes as evidenced by the Ischian catastrophes of 1881 and 1883.

After showing that there is no necessary connection between the volcano and earthquake, other than that both are the effects of one great cause; namely, the contraction of the earth's crust on the cooling nucleus and the consequent motion and development of heat by the sinking masses — as suggested by Mallet — he alluded to proofs which had come under his observation in the Sandwich and Philippine Islands, Iceland, and the Mediterranean basin, that *almost all extended modern earthquakes* have been the result of *subsidence and not explosions.* He instanced Japan, Lisbon, Port Royal, Java, Kilauea, Thingvalla, Taal, Val del Bove, Missouri, the Yosemite Valley, and finally Ischia. He then gave a description of the latter island, its geological structure, its volcanic phenomena and his reasons for agreeing with Prof. Palmieri that it was due to subsidence and not to any resumption of volcanic activity in Epomeo which has been quiet for six centuries. He exhibited views, taken on the spot, of the destruction of buildings. On this theory no region can be considered as exempt from earthquakes, as the earth's cooling goes on. [The paper has been privately printed, and will be sent by the author to any one interested.]

General Meeting, January 16, 1884.

Ex-President, Mr. T. T. Bouvé, in the chair. Forty persons present.

The following papers were read: —

ON THE RELATIONS OF THE CONGLOMERATE AND SLATE IN THE BOSTON BASIN.

BY W. O. CROSBY.

In my "Contributions to the Geology of eastern Massachusetts,"[1] I have expressed the following general conclusions concerning the stratigraphy of the uncrystalline sediments of the Boston basin:

1. There are no Carboniferous beds in the Boston basin.
2. There is in the Boston basin essentially but one formation of conglomerate and one formation of slate.
3. These sediments, including the Paradoxides bed in Braintree, all belong to the same essentially continuous and conformable series, and are, therefore, all of Primordial, or at least of Cambrian age.
4. The conglomerate underlies the slate.

Although the validity of these conclusions has recently been called in question, I am still convinced that they are substantially correct; and my present purpose is to review the evidence upon which they rest and to answer the arguments which have been advanced against them.

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[1] Occasional Papers, Boston Soc. Nat. Hist., vol. III.

1. It has long been a favorite notion with the geologists of this region that the Roxbury puddingstone, if not all the conglomerate of the Boston basin, is of Carboniferous age. There is no evidence supporting this view beyond the fact that the Carboniferous beds in the Narragansett basin are largely a distinct conglomerate resembling that about Boston. Since the publication of my "Contributions," Mr. G. H. Barton and I have made a careful study of the Carboniferous strata along the north side of the Narragansett basin; and we have proved by paleontologic and stratigraphic evidence that the long narrow arm of this basin reaching north easterly from Rhode Island to the Blue Hills contains only Carboniferous sediments. This branch of the great Carboniferous basin, which is called the Norfolk County basin, terminates within one mile of the border of the Boston basin, affording an excellent opportunity to compare the rocks of the two basins.

The Carboniferous shales and sandstones, except when distinctly carbonaceous, are usually green or red, and are quite distinct lithologically from the slates of the Boston basin. The conglomerates of the two basins are also noticeably unlike, the Boston conglomerate being as a rule much stronger, much more thoroughly consolidated, and alternating less frequently with beds of sandstone and slate. Both basins are bordered chiefly by eruptiue rocks, granite, felsite, diorite, diabase, etc., and in the case of the Boston basin it is clear that the eruption of some of these took place after the deposition of the conglomerate and slate. But in the Carboniferous basin evidence of this kind is completely wanting. Nowhere is there any indication that the granite or other eruptive rocks forming the borders and probably the floor of this basin reached their present positions subsequently to the deposition of the Carboniferous sediments. For example, the Blue Hill range of granite forms the southern border of the Boston basin and the northern border of the Norfolk County basin. At most points where this granite meets the conglomerate and slate of the Boston basin its relations to them is that of an exotic. But on the southern side, where it adjoins the Carboniferous strata, the relation is entirely different, all the granite being clearly older than these sediments, proving that the latter belong to a later period than the rocks of the Boston basin. Again, preceding, during and following the deposition of the conglomerate in the Boston basin there were extensive outflows of basic lavas, now commonly known as amygdaloid, which are believed to be entirely wanting in the Carboniferous basin.

Finally, the conglomerate and slate of the Boston basin are traversed in all directions by numerous and large dikes of trap or diabase, so that it is rather exceptional to find large exposures of either of these rocks which do not show one or more dikes. Some of these dikes are from one to several hundreds of feet in width and several miles at least in length; and there can be but little doubt that many of the dikes cutting the crystalline rocks outside of the Boston basin are of the same age. Now, if the Boston conglomerate is Carboniferous then these dikes must be post-Carboniferous; and it is in the highest degree improbable that this immense volcanic activity, which has made the Boston basin a complete network of dikes, would not be felt in some degree at least in the adjacent Norfolk County basin, the shortest distance between them not exceeding one mile. But Mr. Barton and I have examined every ledge in the Norfolk County basin, and in the adjacent portions of the Narragansett basin, without finding a single dike or any trace whatever of any eruptive rock newer than the Carboniferous beds. Excepting possibly one very small dike in the neighborhood of Canton. And Mr. T. Nelson Dale, who has made a careful study of the Carboniferous beds in the vicinity of Newport, tells me that there appears to be a complete absence of eruptive rocks in that part of the Carboniferous basin.

To sum up, although in both basins the rocks are strongly folded and have high dips, yet in the Boston basin all the rocks, including the conglomerate, are distinctly more consolidated and older looking; and preceding, during and following their deposition this basin, including probably the surrounding region, was the scene of the most intense volcanic action, while no eruptive rocks have ever been discovered in the adjacent portion of the Carboniferous basin. In the complete absence of paleontological evidence pointing to a contrary conclusion, these facts certainly require us to believe that all the sediments of the Boston basin are pre-Carboniferous.

2. I have never observed in either the slate or the conglomer-

ate of the Boston basin lithological or stratigraphical peculiarites which are so localized as to afford a proper basis for, or even suggest, a chronological division. The most general distinctions are those resulting from a gradual passage from the normal type of conglomerate into finer varieties and sandstone and from these into slate; but here the evident gradation destroys the inference. The slate, especially, is a very variable rock. The principal colors are black, bluish black, gray, greenish, purplish and brownish red. It may be very thin bedded and beautifully laminated, or so massive as to appear unstratified. It may possess a well marked cleavage or joint structure, or both these may be almost entirely wanting. But none of these differences admit of correlation with the distribution. Locally these rocks are subject to great variations, but to the general view they are decidedly homogeneous.

In my "Contributions" I have shown that the almost perfect agreement in strike and dip, relations to the granite and lithological and mineralogical characters, of the slate in and near the Paradoxides quarry, in Braintree, on the north side of Hayward's Creek, in Quincy, on the east side of Weymouth Fore River, in Weymouth, and along the Monatoquot River, places their essential identity beyond reasonable doubt. Between Quincy Point and the Old Colony Railroad there are no outcrops; but west of the railroad the slate is exposed immediately north of the granite, and agrees in all important respects with that in the vicinity of the Paradoxides quarry and Weymouth Fore River. This comparative study has been extended over the entire basin, with substantially the same results; the facts everywhere favoring the view that the slates are all of the same age; though, of course, the proof becomes, on the whole, less conclusive the further we recede from the fossiliferous beds. Occasionally, however, we find unique evidence connecting the slates of widely separated localities. Thus the slate forming East Point, Nahant, is, in its relations to the eruptive rocks which border it and in the alteration which it has suffered, identical with the slate at Mill Cove, in Weymonth, and like that it holds thin beds of limestone. The character of the limestone and its mode of occurrence, are the same at the two localities, although thirteen miles apart; and the evidence of synchronism is much strengthened by the fact that these are the only points in the Boston basin where limestone is known to occur. The occurrence of fragments of Paradoxides in the drift of George's Island, six miles north-northeast from Hayward's Creek, is a strong indication that the slates are of the same age in distinct portions of the basin. The slate on the extreme northern edge of the basin, in Malden, is indistinguishable from that in the Paradoxides quarry. And much of the slate in Somerville and in the West Roxbury and Dorchester belt is very similar to that in the South Shore district.

Such differences as are noticed in these rocks may often be traced to peculiarities in the local conditions at the time the rocks were formed. Thus, although the conglomerate is made up of pebbles of about all the crystalline rocks of this region; yet its composition is usually influenced by the character of the adjacent crystallines; a conglomerate adjoining felsite being largely composed of felsitic débris, while one adjoining granite is likely to be full of granite pebbles, and the proximity to amygdaloid usually insures the presence of numerous pebbles of this rock in the conglomerate. I will not now advert to the evidence proving that during the deposition of the conglomerate and slate the Boston basin had approximately the form now indicated by the boundaries of these rocks, being merely a westward extension of the modern Boston Harbor, with, of course, a greater width. But I am satisfied that this view is correct; and it assists us in explaining the character of the sediments in the different portions of the basin. For instance, the only two localities where limestone is known to occur — Nahant and Weymouth — are in the most seaward portion of the basin and far from the old shore-line, the source of the sediments. And it is in this direction, in Nahant, the harbor islands, Somerville, Cambridge, the eastern part of Boston and Dorchester, and the South Shore district, that the slate is finest and most homogeneous. On the other hand, we find in the more remote portions of the basin, as in Needham and Natick, only such sediments as would be likely to be formed in narrow and quiet arms of the basin well cut off from the main body. The conglomerates here are fine grained and slaty, being generally composed of soft materials, although hard rocks are abundant among the adjacent crystallines, and the slates are large of a brown or red color, showing an abundance of ferric oxide, which is common with estuary deposits, but rare in those deposited in the open sea. The red color and flinty hardness of some of the slates, and of some of the arenaceous beds in the conglomerate, are due to the baking effect of the adjacent eruptive masses.

The conglomerate and slate occur principally in large masses, each rock covering tracts some of which are ten to twenty square miles in extent. All the areas of these rocks are elongated in an east-west direction, parallel with the general line of strike and the axis of the basin; so that a north-south traverse shows several alterations of belts of conglomerate and slate. The correct and, I believe, generally accepted explanation of this feature of the basin is that it indicates a series of anticlinal and synclinal folds, the crests of the latter having been eroded so as to expose the underlying rock. As I shall show later, the conglomerate is the underlying rock, and hence its position is anticlinal and that of the slate is synclinal. This relation is clear enough in most cases, but the narrow band of slate running through Brookline and the southern part of Newton is involved in an inverted fold so that the conglomerate above the slate appears to be distinct from that below it. This view is further strengthened by the appearance of unconformability between the slate and overlying conglomerate. Dr. Wadsworth has recently attempted to show that these facts prove the existence of a formation of conglomerate newer than the slate. But I think it will appear later that the interpretation of the facts proposed by me is more natural and satisfactory.

The general separateness of the conglomerate and slate is an important and well established fact; for, although beds of fine materials, sandstone and even slate, are of common occurrence in the conglomerate, yet they are essentially a part of that rock are always of limited extent, and clearly to be distinguished from the great mass of the slate. Along the contact between the conglomerate and slate, especially, there are frequently several alterations of beds of conglomerate, sandstone and slate; but they are clearly beds of passage and do not invalidate my general conclusion that there is, taking a general view, but one conglomerate and one slate.

3. The continuous and conformable deposition of the conglom

erate and slate is shown, not only by a general agreement in strike and dip, but also by the phenomenon observable at many points of a gradual lithologic passage between them. As a rule, the portions of the conglomerate showing the maximum of coarseness and irregularity are those in immediate contact with the underlying crystalline rocks. Here the conglomerate is sometimes a genuine breccia and often holds fragments or boulders of large size. Passing upward, this gives way to the more normal and common type of conglomerate, the true puddingstone, in which the pebbles rarely exceed six inches in diameter and are well rounded. Still higher, limited beds and patches of grit and sandstone are intercalated, and these appear more frequently as the pebbles become smaller, finally including layers of slate; and thus the formation is gradually changed from a coarse conglomerate to an impalpable slate. From the earliest conglomerate to the latest slate the deposition has evidently been substantially uninterrupted, and has gone on during a period of subsidence with which the growth of the deposits did not keep pace.

Indications of this gradual passage between the conglomerate and slate may be observed at most points where there are outcrops along their mutual boundaries. But it is, perhaps, best displayed at the following localities: At several places in Hingham; on the Old Colony Railroad between the Wollaston and Quincy Stations, and along Black's Creek one-fourth mile west of the railroad; near the New York and New England Railroad in Mattapan; North Quincy, one-half mile northeast of Atlantic Station; the shore on the outer end of Squantum; Mt. Hope Cemetery; between Florence Street and Hyde Park Avenue, near Mt. Hope Station; Newton Centre; Newton Upper Falls; Newton Corner; and in the neighborhood of Grantville and of South Natick.

The statement has been made that the slate as a whole is characterized by steeper dips than the conglomerate. But I have not been able to verify this observation. Both these rocks are, for the most part, highly inclined, often vertical. In fact, they have suffered an enormous amount of disturbance, chiefly in the form of folds, faults and igneous intrusions; and, in consequence, adjacent outcrops of conglomerate and slate sometimes show very discordant dips. But the same sort of evidence would prove unconformability between different portions of the slate, and different portions of the conglomerate. While the general fact remains that adjacent ledges of the two rocks usually show a perfect agreement in strike and dip; and when the actual contact between the conglomerate and slate is exposed they are always perfectly conformable, except at the ledge on Beacon Street in Newton Centre; and here, as I will show later, the unconformable contact is due to irregular faulting and not to erosion.

4. In the statement that the conglomerate underlies the slate I do not mean to assert that it is older than all the slate; for it is probable that these rocks are in part contemporaneous deposits, slate in the deeper water and conglomerate in the more shallow, being formed simultaneously. In other words, the deposition of the conglomerate began first, but had not entirely ceased in some parts of the basin, when the deposition of the slate had begun in other parts; so that chronologically the two deposits overlap, and have not everywhere the same relative thickness.

The principal facts proving that the conglomerate underlies the slate are: —

(1) At most points around the margin of the basin the conglomerate comes between the slate and the crystalline rocks. In many places, it is true, this conglomerate border appears to be wanting; but the most important of these apparent exceptions occur where the rocks are entirely concealed by drift, and we can not know with certainty what they are. This is the case along nearly the whole of the north side of the basin; yet toward the southwest, in Needham, and toward the northeast, in Medford, the conglomerate very plainly intervenes. In some of these exceptional cases, again, there are indications of faults which, with the downthrow on the side toward the slate, have carried the conglomerate below the present surface. In still other instances the contact of the slate with the bordering crystallines may, with considerable probability, be regarded as true overlap resulting from the progressive subsidence during and preceding the deposition of the slate. This explanation seems applicable at some points in the South Shore district. The geographical relation here insisted upon is best shown around the three peninsulas or tongues of the ancient formations (eruptive rocks) which project into the basin from the west. The isolated masses, or

islands, of the crystalline rocks, such as occur in Milton, Hyde Park, etc., are usually entirely surrounded by a zone of conglomerate.

(2) The conglomerate almost invariably dips toward the outcrops of slate, and in not a few instances can actually be seen to pass beneath that rock. The reverse of this sometimes occurs, as in the Beacon Street section near Newton Centre; but this is most naturally explained as due to an inversion of the beds — an explanation which, however, will not apply in the far more numerous cases where the conglomerate is the underlying rock. Following is a list of the localities where the superior or synclinal position of the slate is clearly shown: — Several points in the northwest part of Hingham, as described in my "Contributions;" vicinity of Black's Creek, in Quincy, the slate south of the conglomerate dipping toward the south, and that north of the conglomerate dipping toward the north; several of the patches of slate in the valley of the Neponset; North Quincy, one-half mile northeast of Atlantic Station; all along the Dorchester and West Roxbury belt of slate, but especially in and near the Mt. Hope and Forest Hills Cemeteries; in the vicinity of Newton Centre, and Chestnut Hill Resevoir; Newton Corner and South Natick; and the square in Watertown bounded by Mt. Auburn, School, Belmont, and Grove Streets.

In short, save where occurring on the margins of the basin, or exposed through the agency of faults, the conglomerate never comes to the surface except through denuded anticlinals from which the slate has been eroded away; though in some cases the conglomerate too has been worn through, bringing into view the crystalline axis beneath.

The supposed occurrence of pebbles of the slate in the conglomerate has been confidently appealed to as conclusively proving the greater antiquity of a portion at least of the former rock; but after a critical examination of many hundreds of these "slate pebbles," I am fully convinced that I have not seen a single genuine pebble that can be clearly identified with any part of the slate formation now exposed to observation. Many seeming slate pebbles are merely very limited, lenticular layers of slate intercalated in the conglomerate. Good examples of such false pebbles resulting from irregular sedimentation occur in North

Quincy, at Squantum, and on the north side of North Beacon Street, in Brighton. The conglomerate of the last named locality is well known, and several observers have noted the occurrence in it of the "slate pebbles." A careful study, however, has satisfied me that the pebble appearance is illusory in most cases at least, these masses being indigenous in their present positions, and not imported. In most cases the material seems far too shaly and fragile for the formation of transportable pebbles of the sizes observed; the largest being a yard or more in diameter and yet only two or three inches thick. And the rare occurrence of the so-called slate pebbles, except along particular planes in the rock, where they are numerous, is decidedly a suspicious circumstance; while peculiarieties of form in many cases, as where they envelop pebbles of other material or enclose arenaceous strings which are continuous with the general paste of the conglomerate, seem to complete the proof. But the evidence is still more convincing in North Quincy and Squantum.

Pebbles of partially decomposed felsite are easily mistaken for slate pebbles, and the felsitic débris is exceedingly abundant in the conglomerate. Many pebbles that seem to be slate are very compact and more or less altered basic eruptive rocks. Among the trap and amygdaloid of the Boston basin it is common to find varieties which are not readily distinguished from slate in hand specimens. I do not deny the possible existence in the conglomerate of genuine slate pebbles; but I do claim that the occurrence of pebbles derived from the Primordial or any more recent slate formation has not been proved. It is important to remember that there are many slaty rocks in eastern Massachusetts outside of the Boston basin, that some of these are almost certainly of pre-Cambrian age, and that, if true slate pebbles occur in the conglomerate, they may have been derived from some of these older slates.

The facts afforded by the artesian well on Providence Street in this city, for which I am indebted to Mr. J. A. Whipple, are of interest in this connection, since they point to the conclusion that the conglomerate is below the slate. This well is 2503 feet deep. Down to a depth of about 2300 feet the rock is slate, the common gray to black varieties, with some arenaceous beds and probably more or less vein quartz. Below 2300 feet the character of the drillings seems to indicate a variety of materials, and is favorable to the view that the rock is conglomerate. And the material removed by the sand pump each morning before drilling commenced, and which consists of fragments that had become detached from the side of the well during the night, includes many small, well-rounded pebbles of quartzite, trap, etc., just those materials which are most abundant in the Roxbury pudding stone. No pebbles were obtained from a less depth than 2300 feet; and the indications are plain that at that depth the well reached the beds of passage between the slate and underlying conglomerate.

The well of the Boston Gas Company, on Causeway Street, is 1750 feet deep; and was bored almost wholly in slate, the last fifty feet only being in a harder rock which is quite possibly conglomerate, although, having seen no samples of the borings, I cannot speak positively on this point. Dr. T. Sterry Hunt has called attention to the fact that in the composition of the water of this well we have a plain indication that the slates yielding the water are of Cambrian age, and, therefore, probably synchronous with the Braintree slate.

Some of the larger dikes of diabase cutting through the slates include fragments of quartzite similar to that entering so largely into the composition of the conglomerate. Some of these fragments may have come, as Dr. Wadsworth suggests, from a formation of quartzite underlying the slate; but others, it is clear, cannot have been derived directly from this source, because they are well rounded or water-worn pebbles such as could only have come from a formation of conglomerate below the slate.

The angular fragments of quartzite enclosed in dikes traversing the slate and the fact that this is by far the most abundant material in the conglomerate, which is often entirely composed of pebbles of quartzite, while the only quartzite of similar character now exposed on the surface is limited to a small area in Wellesley and Natick, lend much probability to the view that the conglomerate and slate rest in part upon quartzite. According to Dr. Wadsworth, this conclusion is confirmed by borings in various parts of the Boston basin; and it is only in this way that we can find an adequate source for the pebbles in the conglomerate. But, if the slate underlies the conglomerate, then all this quartzite was buried before the conglomerate was made, and none of the quartzite forming the floor of the basin can be regarded as a possible source of the conglomerate pebbles.

It is certainly probable that the slate and conglomerate were deposited on a subsiding sea-floor. But, if so, then the formation of the conglomerate must have commenced first, although the two rocks are in large part contemporaneous deposits, as already explained.

There is certainly no good reason to doubt that in its lithological aspect the conglomerate is as old as the slate. Both rocks are thoroughly consolidated, the cement of the conglomerate being quite as strong as the slate and often approaching in hardness the pebbles which it encloses. Both rocks are frequently locally altered by intrusives. From the nature of the case, the alteration is most noticeable in the slate; but it is sometimes very marked in the conglomerate, as in that along Adam Street in Quincy, which is altered by the Quincy granite. Even the cleavage structure which frequently appears in the slate, is matched in the conglomerate, appearing in those varities in which pebbles of pinite and slaty rocks predominate, the pebbles being flattened by the pressure. The cleavage planes in the conglomerate agree perfectly in dip and strike with those in the slate.

I will now attempt to answer the particular objections which Dr. Wadsworth has advanced against the foregoing views of the stratigraphy of the Boston basin. Dr. Wadsworth's exceptions to my conclusions are contained chiefly in two papers.[1] The first paper relates to the rocks on and near Central Avenue, in Milton, in the area between Pine Tree Brook and the Neponset River. The relations of the rocks in this interesting locality were described by me in my "Contributions" (220 and 270), and in the Amer. Jour. Sci., 1880 (3), XIX, 116.

I have stated that the oldest rock exposed on Central Avenue is a ledge of purple felsite which is altered superficially to greenish pinite. That after this alteration took place, conglomerate was deposited over and around this ledge and that in the immediate vicinity of the ledge it is largely made up of the débris of both the unaltered felsite and the pinite. That the conglomerate, which has been removed from the top of the felsite by eroion, can be seen in contact with it on the north side, the surface of contact being a fault plane trending nearly east-west and inclined to the north about 75°. That parallel with this fault the conglomerate, which, from the predominance of the pinite débris, is largely of a soft and slaty character, exhibits a well-marked cleavage structure, the pinite pebbles being flattened and the rigid felsite pebbles broken in a way to indicate a powerful compression in a direction normal to the fault-plane. And, finally, that the strike of the conglomerate is northeast and southwest, the dip very steep to the southeast, and that this is clearly shown in a ledge on Central Avenue a few rods southwest of the felsite ledge. Here a coarse conglomerate or breccia alternates with layers of sandstone, so that the stratification is very plain.

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[1] Harvard University Bulletin, II, 431, Proc. Boston Soc. Nat. Hist., XXII, 130.

Every important proposition which I have affirmed in this statement is denied by Dr. Wadsworth. He says that the felsite is merely a portion of the conglomerate altered by thermal waters; that the strike of the conglomerate is east-west, the bedding being parallel with the fault-plane and the supposed cleavage, which he says is not cleavage, but merely stratification. He says, further, that the large, angular fragments in the breccia are slate resembling the slate on the railroad one-third of a mile northeast of this locality; thus proving that the conglomerate is younger than the slate.

First, with regard to the felsite. The contact between it and the conglomerate is well defined. On one side of a perfectly definite plane is the soft and distinct slaty conglomerate and on the other side is the purple felsite of almost flinty hardness, and showing no pebbles. This felsite is similar to and almost continuous with that covering a large area in this part of Milton west of Central Avenue and south of the Neponset River. In the neighboring ledges there are two varieties, white and purple. These occur separately, irregularly mixed, and very regularly and beautifully banded or interlaminated. Traces of this banding are observable in the ledge of felsite on Central Avenue. Dr. Wadsworth says this felsite contains many argillaceous pebbles but partly obliterated. These supposed pebbles are in part the irregular and broken banded structure and in part are due to the crushing of the rock along the fault. All geologists know that what are called crush breccias are of common occurrence in the neighborhood of faults. Several good examples of crush breccia are to be seen in the slate on the railroad, near Central Avenue; and in this way limestone and many eruptive and crystalline rocks may take on a conglomerate structure. The undoubted felsites of eastern Massachusetts very commonly contain pebbles; and a breccia texture due to included fragments is one of their most common characteristics, as Dr. Wadsworth will probably agree. Possibly some of the supposed pebbles in the Central Avenue felsite may be accounted for in this way. This rock certainly looks like a felsite, and I think we must regard the conglomerate theory of its origin as uncalled for until it is proved to contain pebbles which cannot be explained in either of these ways. Dr. Wadsworth says the microscopic evidence bears out his view that the felsite is an altered argillaceous conglomerate. My examinations of the thin sections, on the contrary, show that it is essentially similar to other felsites of this region. Most lithologists will admit that there are rocks whose origins cannot be determined by the microscope; and I believe that this highly weathered, crushed felsite belongs to that class; and I also believe that it presents no characteristics, either microscopic or macroscopic, which are not exhibited in other and undoubted felsites of this region. In this opinion I am sustained by Dr. N. F. Merrill, who kindly examined the thin sections and hand specimens of felsite from this and the adjoining ledges without knowing where they came from or that they were the subject of any controversy.

About three-fourths of a mile from this locality, on the north side of the river and near Mattapan, the contact of the conglomerate and felsite is exposed again and very satisfactorily. The felsite is distinctly banded and the banding is perpendicular to the contact, which is vertical and apparently due to faulting. The conglomerate is a distinct breccia chiefly composed of fragments of this same felsite and of amygdaloid, which occurs near by. Now I think the burden of proof rests upon those who claim that the phenomena presented at this point are essentially different from those on Central Avenue.

If the Central Avenue felsite is really an altered conglomerate, then the soft pinite masses must be the least altered portions, since they are most like the unaltered conglomerate, but they are not in the part of the felsite nearest the conglomerate, nor is there any indication of a gradual passage between the conglomerate and felsite. Furthermore, the segregated veins of quartz, to which Dr. Wadsworth rightly refers as evidence of thermal action, are in the centre of the pinite masses and do not touch the flinty felsite. Hence they are evidence that the pinite is the most highly altered portion of the rock, resulting from the hydration of the felsite by meteoric waters which have followed the course of the quartz veins and decomposed the felsite on either side. The purest and greenest pinite is next to the quartz, and from this there is a *gradual* passage within a few inches to the unaltered purple felsite. These small veins of quartz are common in both the conglomerate and felsite of this region. The composition of both the pinite and felsite, as shown by chemical analyses, is favorable to the view that the former has resulted from the alteration of the latter, while it is difficult to see how hydrothermal action could give the pinite or the pinite conglomerate the composition of the felsite. One of the strongest arguments against Dr. Wadsworth's view is the undeniable fact that the conglomerate is composed of the débris of this same purple felsite and green pinite, and the conglomerate has this peculiar composition only in the immediate vicinity (within a few rods) of the felsite. The source of the pebbles is plain; and I think we have here entirely satisfactory evidence that the felsite is older than the conglomerate. The relations of the two formations would scarcely be clearer if this were a ledge of granite surrounded by a conglomerate composed of pebbles of the same granite. And there is not a shadow of proof that the pinite débris has been produced in the conglomerate. Pebbles of this mineral are common in the conglomerate in all parts of the Boston basin, and it is always clearly an imported constituent. Dr. Wadsworth apparently set out to contest the view that the Boston conglomerates are younger than the felsites of this vicinity; an undertaking that would seem to have been hopeless from the beginning, in view of the facts that every variety of felsite occurring in this region is represented in the pebbles of the conglomerate, and that the felsite pebbles are abundant in all parts of the conglomerate, and not alone in the Milton conglomerate.

The felsite ledge does not extend across Central Avenue; but Dr. Wadsworth says it would do so, "unless gratuitous hypotheses are resorted to to support the felsite theory." If we cannot legitimately suppose a ledge six feet high on one side of a street without its counterpart on the other side, then the thoroughfares of New England are lined with facts sustaining gratuitous hypotheses. The felsite can be traced about one-fourth of the way across the avenue, and I have no doubt that it underlies the conglomerate on the opposite side.

No structural feature of the conglomerate is plainer than its cleavage. The rock is eminently shaly in planes parallel with the fault; and all the soft pebbles are flattened and nearly all the hard pebbles are broken in directions requiring powerful compression at right angles to the easy splitting or cleavage. It is not easy to conceive a more perfect cleavage in a rock of this character. As already indicated, the cleavage planes strike about east-west and dip steeply to the north, agreeing in these respects with the cleavage of the slate throughout the Boston basin. One-half mile east of the conglomerate on Central Avenue, on the east bank of the Neponset, are conglomerate and sandstone interstratified and dipping at a high angle to the south. The sandstone is also traversed by very perfect cleavage-planes dipping steeply to the north as usual. The conglomerate layers being composed of hard pebbles, are insusceptible of cleavage; but if they were wanting, the cleavage of the sandstone might easily be mistaken for stratification. Following the same belt of rocks still farther east, we find on the shore of Squantum a slaty conglomerate with distinct cleavage which, as before, dips steeply to the north, while the bedding is inclined to the south.

Dr. Wadsworth has mistaken the cleavage of the Central Avenue conglomerate for stratification; and he says "that pebbles that would be readily affected by pressure lie across the supposed cleavage planes exactly as they would if these were bedding planes." I do not believe it is the general experience of geologists that pebbles in a conglomerate lie across the bedding planes. Again, he says that the lines of coarser and finer sedimentation prove that these planes of easy splitting are bedding planes. In company with Prof. W. H. Niles, I searched carefully for these lines of finer and coarser sediments coinciding with the cleavage, but we could not find any indication of them.

The development of the cleavage has nearly effaced the original structure lines of this part of the conglomerate; but indubitable traces of the bedding still remain. On both sides of the avenue, but especially on the southeast side, there are thin beds of purplish slate in the conglomerate, and also layers of coarser and finer pebbles, all showing a very high dip to the southeast. The avenue runs S. 35° W., and the strike makes an angle of about 10′ with the avenue, being southwest, and not east-west, as Dr. Wadsworth claims. The entire independence of the stratification and cleavage is apparent even in hand specimens of the conglomerate. At the ledge of sandstone and breccia further to the southwest on the avenue, the stratification, as Dr. Wadsworth truly says, is remarkably distinct. But it passes my comprehension how he could find the line of strike here to be east-west; and I am confident that he would not should he again visit the locality. There is simply no room for a difference of opinion here, but the facts clearly sustain my original statement that the strike is S. 45° W. and the dip S. E. about 75°, both being entirely at variance with the cleavage.

Finally, the large, angular fragments in the breccia do not resemble the slate on the railroad, nor any other slate occurring in that region, so far as I have observed. The slate forming the anticlinal on the railroad is greenish gray and so distinctly and finely stratified that one could scarcely obtain a fragment three inches in diameter that would not show the bedding lines. But the fragments in the breccia are of a very dark grayish black color, and, although they are very numerous and the largest are two feet in diameter, yet none of them show the slightest trace of bedding. They have the general aspect of slate, but the microscopic examination of thin sections shows that they are probably a highly altered eruptive rock or trap. Large ledges of compact and slaty trap occur all about the breccia, and many of the dike rocks of this vicinity are of similar appearance to the fragments in question, and are not easily distinguished from slate. Hence it cannot be claimed that these fragments prove the post-Primordial age of the breccia.

In the same paper, Dr. Wadsworth, after noting the generally admitted facts that the granite is eruptive at some points through the slate, and that granite pebbles are abundant in the conglomerate, asks how it is possible, in view of these facts, to regard the conglomerate as underlying the slate? In reply I would say that the granites surrounding the Boston basin have an area of nearly 200 square miles and present many varieties; that it is in the highest degree improbable that they are all of the same age; and that at some points, as in Hingham, the granite is undoubtedly eruptive through both the conglomerate and slate, the same conglomerate holding pebbles of granite. Pebbles of basic eruptive rocks — trap, melaphyr, amygdaloid, etc. — are common in the conglomerate; but we cannot argue from this fact that the conglomerate is newer than all the rocks of this class, because the conglomerate is traversed in all directions by dikes and eruptive masses of these same exotic rocks.

The second paper by Dr. Wadsworth relates to the unconformable contact of the slate and conglomerate on the north side of Beacon Street, Newton Centre. It does not appear from this paper that the unconformability of the slate and conglomerate at this point had been previously observed, but Dr. Wadsworth describes it as if it were an original discovery and distinctly says that "the proof of the unconformable superposition of the conglomerate upon the argillite has been overlooked by Mr. Crosby." Yet, in my Contributions this unconformability is described in greater detail than by Dr. Wadsworth and on several different pages I have stated that the contact is clearly unconformable. What I have denied, and still deny, is that the unconformability is due to erosion and that the slate is older than the conglomerate.

It is a common saying that by isolating facts, or taking them out of their normal relations, we can prove almost anything. This adage is especially true when applied to the geology of such a complicated district as the Boston basin. Taken by itself, the ledge on Beacon Street does show all that Dr. Wadsworth claims, except that it will require stronger evidence than has yet been offered to prove that the fragments in the conglomerate supposed to be pebbles derived from the underlying slate really are such.

There is little room to doubt that the slate at Newton Centre is part, although, through excessive disturbance, possibly now an isolated part, of an east-west belt of slate extending from Boston across Brookline and Newton to the Charles River at Newton Upper Falls. This belt, which appears to have a breadth of a mile in Brookline, contracts rapidly toward the west; and in this contracted portion it is well exposed; in and around Chestnut Hill Resevoir, where it is scarcely less than one-fourth of a mile wide; on Beacon Street, Newton Centre, where it can hardly be more than 250 feet wide; and in the vicinity of Newton Upper Falls, where the width is probably not less than 600 feet. The dip of the slate is northerly at all points and very variable, ranging from 20° to at least 70°, although usually between 30° and 40°. Lithologically, this slate shows but little variation, being gray, distinctly bedded, with usually a very perfect cleavage parallel with the bedding and frequent contortions.

The slate belt is bordered on either side by a broad belt of conglomerate. The conglomerate on the south side of the slate is three-fourths of a mile to a mile wide, and that on the north is about two-thirds as wide. But we have no reason to suppose that the actual thickness of the conglomerate in the two belts differs materially; for the southern belt is characterized by gentler dips than the northern, the beds on the southern border of the southern belt being sometimes nearly horizontal, while in the north belt the dip is sometimes nearly vertical. At all points the dip is northerly, and averages about the same as for the slate. I think it is impossible to establish any lithological distinctions between these two belts of conglomerate, but they appear, rather, like different parts of the same formation. Furthermore, it is almost certain that at the western end they are continuous around the slate, as shown on the map accompanying my "Contributions."

Outside of the two conglomerate belts are two broad belts consisting chiefly of basic eruptive rocks which I have mapped as amygdaloid. It is probable that these are in part older than the conglomerate. But, whatever their age, it is certain that the southern amygdaloid belt marks the position of an important anticlinal axis; and it is probable that the northern belt does also.

To my mind, these facts suggest very forcibly that the two belts of conglomerate, with the belt of slate between them, are involved in a closed synclinal fold having its axial plane inclined to the north. The relations of the slate to the conglomerate on the south are sufficiently clear at Newton Centre and Newton Upper Falls. This belt of conglomerate becomes smaller-pebbled toward the north, and in the upper 300 feet includes several beds from one to twenty feet thick of brown and gray sandstone and slate; thus passing gradually into the main belt of slate, which it underlies conformably. The relations of the slate to the conglomerate on the north have been observed at only two points — Newton Centre and Chestnut Hill Resevoir. At the latter locality, the conglomerate, like that south of the slate at Newton Centre, is small-pebbled and includes several beds of slate and sandstone — beds of passage between the two formations which are here also perfectly conformable. These facts greatly strengthen the view that these two belts of conglomerate are of the same age, and continuous *under* the slate, as they seem to be around its western end. And, following this slate eastward, we come to the Providence Street well in which, as already described, we see a great thickness of slate apparently resting on conglomerate. The perfect cleavage parallel with the stratification which the slate shows at most points is also favorable to the view that it has been mashed up in a closed fold, experiencing in this way much greater compression than that due to the mere weight of the overlying beds.

This view is consonant with all the facts so far referred to; and affords the only explanation of the stratigraphy that harmonizes well with the facts observed elsewhere in the Boston basin. For, on the other hand, if the synclinal view is rejected, we at once double the thickness of the entire formation, and have to consider that the two great and distinct conglomerates, with the slate between them, all dip to the north against the broad belt of amygdaloid, which thus becomes a dike nearly a mile wide, instead of what it more probably is, outflows and sheets of lava. And where these sedimentary rocks come to the surface again it is impossible to determine. Neither could we on this supposition satisfactorily explain the fact that the slate between these two belts of conglomerate varies in thickness from perhaps 150 feet to at least 600 or 800 feet in a little more than a mile. But the explanation of this variation is easy and natural, if we suppose a synclinal deeper, and hence including more of the overlying slates, at some points that at others.

Here we have a whole series of facts demanding a synclinal position for the slate; and what are the facts opposed to this view? Simply this: the northern conglomerate rests unconformably upon the slate at Newton Centre. But the same contact is perfectly conformable at the Chestnut Hill Resevoir. Besides, every geologist knows that unconformable contacts may be due to disturbance and faulting as well as to erosion; and I think Dr. Wadsworth has failed to prove that the Newton Centre contact necessarily belongs to the latter class. He says this is not a fault, because the slate and conglomerate are united in a solid mass. But this certainly is no unusual feature of faults. Why should not two rock surfaces that have been in contact under enormous pressure during long ages be firmly united? I find, however, on a careful reëxamination of the contact, that at most points the slate and conglomerate are not united. On the other hand, if, as so many important considerations require us to suppose, this is an overturned synclinal, then the plicating force must have been greatest from the north; *i. e.*, in the right direction to produce just such oblique fractures as the one in question. And it is important to remember that a slip of a few feet or yards along this irregular fracture would give rise to all the unconformability observed.

That oblique faulting has occurred along this boundary line between the slate and conglomerate is proved beyond the possibility of a doubt by the fault exhibited in the east bank of the Chestnut Hill Reservoir, and which is described and figured in my "Contributions." Now all that the synclinal theory requires is that the Newton Centre unconformability should be explained in the same way as that at the reservoir on the same stratigraphic line. If, as Dr. Wadsworth supposes, this northern belt of conglomerate is newer than the slate, it certainly is a strange circumstance that it shows much steeper dips and greater disturbance than the slate on which it rests.

Dr. Wadsworth agrees with me that the Newton Centre slate is probably of the same age as the Paradoxides slate in Braintree. But the Newton Centre slate is unquestionably underlaid by the broad belt of conglomerate on the south of it; and hence Dr. Wadsworth virtually admits that there is in the Boston basin a great formation of conglomerate older than the Primordial slates.

AN OLIVINE, BEARING DIABASE, FROM ST. GEORGE, MAINE.

BY Q. E. DICKERMAN AND M. E. WADSWORTH.

During the winter of 1879–80 two of the masters of one of the Boston schools spent their spare time in studying microscopical lithology at the Museum of Comparative Zoölogy under the direction of one of the writers of this article. One of these teachers (Mr. Dickerman) became much interested in the above mentioned rock from the quarry of the Long Cove Granite Company, situated near Tennant's Harbor, opposite Spruce Head, St. George, Maine. He wrote out at the time a description of the microscopic characters of the rock which has since been revised by Mr. Wadsworth and is now published.

The rock is sold in the markets of New York and Boston under the name of "Black Granite." It is of a dark gray color, crystalline in structure, and shows numerous milk white striated feldspars. On the polished surface magnetite, pyrite, and feldspar can readily be determined. In the thin section the rock is seen to be composed of augite, olivine, feldspar, magnetite, hornblende, biotite, and pyrite.

The feldspar is generally striated although some does not show twinning when examined in polarized light. It forms the larger portion of the section. While the feldspar is generally water-clear, it is frequently somewhat kaolinized along the fissures and in spots elsewhere. It contains in places numerous elongated, staff-like, and lenticular black bodies, which were also seen in minute rounded forms. These bodies are generally arranged parallel to the cleavage. The feldspar further contains inclusions of augite, biotite, olivine, magnetite, and pyrite.

The augite is in large irregular patches surrounded by the feldspar. The cleavage is in part the irregular fissuring of augite and in part the parallel longitudinal cleavage of diallage, hence, the rock in the common nomenclature might either be called diabase or a gabbro. The augite is quite full of the same black bodies as the feldspar, which in places are so abundant as to render the crystal nearly opaque. The augite contains also magnetite, pyrite, feldspar, and olivine. It is frequently altered to a coffee-brown biotite and hornblende, especially on the borders, and on the long tongues extending into the feldspar.

The olivine is in irregular fissured grains usually surrounded by or adjacent to the augite, but it is occassionally observed entirely surrounded by feldspar. Frequently along the fissures it is filled with magnetite or by a greenish serpentineous product. It further contains inclusions of feldspar, magnetite, pyrite, etc.

The magnetite is in irregular grains generally surrounded by a border of secondary biotite or hornblende. It is associated with and frequently surrounds the pyrite.

Similar rocks have been described by Mr. G. P. Merrill in the Proceedings of the National Museum, 1883, VI, 176, 177.

Mr. S. Garman showed a very remarkable selachian from Japan, which he had described under the name of Chlamydoselachus anguineus.[1]

General Meeting, February 6, 1884.

The President, S. H. Scudder, in the chair. Twenty-nine persons present.

The following papers were read: —

THE GENESIS OF THE BOSTON BASIN AND ITS ROCK FORMATION.

BY THOMAS T. BOUVÉ.

The paper upon the conglomerate and the slate of this neighborhood read at our last meeting by Mr. Crosby, and the prolonged discussion which followed participated in by Dr. Wadsworth, Prof. Niles, and myself have led me to present some views upon the Boston basin of a more comprehensive character than such as deal only with the relative age of the rock-formations contained in it, as it is possible that a study of the probable origin of the basin itself and the consequent phenomena, may throw some light upon subordinate questions concerning the strata found within its area.

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[1] Science, vol. III, 116. Bull. Essex Inst. vol. XVI.

It is, perhaps, presumptuous to undertake to present even a very vague idea of the condition of the surface in and about the region now occupied by the rocks of the area known as the Boston basin, at a period prior to their deposition; yet it has seemed to me not unwise to consider somewhat the probabilities, in order to be able to form a reasonable conception of the origin of such strata as now exist in it. Upon the first study of the rocks composing these strata, the questions naturally arise to the mind, where did all the material composing them come from? How is it possible that such a large body of boulders and pebbles could have been brought so together as to make up the vast beds of the conglomerate, and from whence came the immense quantity of fine sediment necessary to build up the one or two thousand feet of clay slates that rest upon or are interstratified with it?

To answer such questions by the general statement that the basin was the result of erosion by the sea, that during long ages in which this took place the worn-away rocks furnished the material from which the conglomerate was built up, and that the fine substance composing the slates was subsequently borne by rivers into the basin, affords no satisfactory reply; for it is altogether inconceivable even to a mind educated to a perception of what can be accomplished through long geological eras, that the erosive action of the waves against a rock bound coast could in any number of ages account for the production of such a quantity of boulders and pebbles as make up the rocks mentioned, and equally so, perhaps, to account for the finer material of the slates without taking into view other and remote causes not hitherto referred to by any writer upon the rocks of the basin, but of which I design to speak. In passing I will remark that what is said in this connection upon these conglomerates will apply with equal force to many vast accumulations, making up like rocks of other regions which have been regarded as the result of erosive action of the sea alone. It will be my endeavor to show that so far as the deposits of the Boston basin are concerned, there were for an unknown period far more potent influences at work towards the production of the boulders and the pebbles of the conglomerates as well as for the great accumulation of the clays, that were eventually consolidated into the argillite, than can be ascribed to causes now in action however prolonged in duration.

Before, however, proceeding further I wish to have borne in mind the apparent fact that the area of the basin, so-called, was one of great igneous activity during and following the deposition of the strata, as is shown by the very numerous trap dikes that everywhere forced their way through the granitic rocks surrounding it, responsive no doubt to the greater action within its limits by which extensive eruptions of similar, if not identical, character were raised to the surface through the conglomerates and slates; or rather, perhaps, through the materials composing them and helping to their consolidation. I refer to the amygdaloids, the exotic character of which seems to me to admit of no question.

The basic character of this rock has led me to infer its derivation from the diorite shown by Crosby's map of eastern Massachusetts to border the basin at Waltham and Belmont, and which may have originally extended over its whole area. The view advanced by another geologist that the amygdaloid has been derived from conglomerate is untenable, as the result of such change would have been the production of an acid exotic and not a basic one.

Having thus spoken of the character of the rocks composing the contents of the basin, let me present such a view of the origin of the great accumulation of sedimentary deposits as appears to me probable. To fully realize all that may be expressed on this point it becomes necessary to consider the unquestionable condition of the whole land surface of the continent, prior to the great ice period during which by glacial action all the superficial materials of the northern portions were disturbed, inextricably mixed, and borne along away from their original resting places to form the great body of the drift.

What was the character of the material making up the whole surface of the land previous to the deposit of the strata of the Boston basin? No one who has studied the subject at all will doubt that it was composed of the wholly or partially disintergrated remains of early formations caused by a process of decay that had been going on for countless ages, facilitated no doubt by an atmosphere more favorable for such action than that of the present period.

Dr. T. Sterry Hunt, to whose view I am glad to acknowledge my indebtedness for much information of a general character which in this paper I apply to local phenomena, when speaking of the decomposition of the rocks referred to, uses the following language:—

"This change has affected the crystalline rocks of the southern United States and of Brazil to the depth of a hundred feet or more, and doubtless extended to all such rocks as were above the surface of the ocean. The absence of this decayed material from certain regions of crystalline rocks is to be attributed to its subsequent removal by denudation, a process which in the northern parts of Europe and America terminated at the close of the Pliocene period, when the remaining softened material was swept away by the action of the water and ice, and the hard unchanged rocks beneath were exposed and glaciated, since which time the chemical decomposition of the surface has been insignificant."

In these words of Dr. Hunt there are two points upon which I wish to comment, because of their bearing upon what I have to say. One is that in relation to the depth of the disintegrated rock material. This is found to be in the region mentioned by him 100 feet or more in thickness. Now I am sure that neither Dr. Hunt himself or any one else will think that this expresses any adequate idea of the probable extent of the disintegrating action, for there were undoubtedly in after ages when such action had largely ceased to operate, influences at work to gradually lessen the thickness of the deposit. In truth no one can venture to say that it may not have been many hundreds of feet thick.

The other point is Dr. Hunt's remark that since "the hard unchanged rocks beneath were exposed and glaciated the chemical decomposition of the surface has been insignificant."

This I wish to intensify by calling attention to the fact that everywhere upon the hard rocks of New England the grooving of the ice period may be distinctly seen, the action of the elements through the ages since they were made, not having sufficied to obliterate them.

There is yet an important general phenomenon to allude to before making application of what has been expressed to the main matter under consideration, and that is, the almost universal exemption of portions of the material of the rock formations that suffered through chemical action from the decomposition that affected the mass, so that there may be always found boulders and pebbles of all sizes unchanged, showing distinctly the original character of the whole. This was probably due to a gradually lessening intensity of corrosive action and finally to its almost entire cessation.

Let us now picture the probable condition of things in and about the Boston basin prior to events which led to its formation. I presume there can be no question but that the country was undulating, with hills of much higher altitude than now, and that the basin itself was a valley extending farther east than at the present day, the land surface reaching continuously beyond where now rest the islands of the harbor. There is too good reason for the belief that then as now rivers flowed through it to the ocean.

Now, if it is admitted, what no geologist will I think question, that the substance of the surrounding hills and valleys was composed of the disintegrated and partially disintegrated rock formations preëxisting in the same localities and that there yet remained disseminated throughout and composing a large portion of the mass, boulders and pebbles not decomposed, we have with the exception of such as was of igneous origin all the material required for the production of the great deposits under consideration.

I wish that what has been said relative to the undecomposed boulders and pebbles remaining in the otherwise disintegrated rock formations of early periods be especially borne in mind, as I believe the production of the conglomerate of the Boston basin, as well as that of many other regions, to have been due mainly to the deposit of this unchanged material where subsequent influences were favorable to its consolidation.

All circumstances conspire to show that at a period anterior to the formation of the basin there commenced a series of the violent igneous disturbances before referred to as having occurred in the region, and which finally led to the more or less gradual sinking of the whole area of the basin until at length the depression reached a depth of nearly or quite two thousand feet. Such depression would of course tend to increased igneous activity beneath, and further eruptions of the underlying melted matter would be likely to come to the surface. This being the case it results that, from the very moment when the first depression brought any part of the disintegrated rock material beneath the water level the waves would commence to act upon it, bearing away much of the lighter portions and acting more or less upon the exposed boulders and pebbles. As the depression increased the waters would spread more and more over the area until the whole was covered. By the greater gravity of the rock masses, the immense body of the boulders and pebbles necessary to form the conglomerate would be brought together at the bottom with only perhaps such portion of the other material intermixed as would serve to form the cementing tie when subsequent influences should lead to the consolidation of the whole; and here it is important to bear in mind that the matrix of the resulting rock is really of the same composition as that of the enclosed masses. In the deposit thus made would be the boulders and pebbles of all the strata that had existed in the superincumbent rock formations, including those from the amygdaloid, which had been injected as an exotic among them.

Simultaneously with the depression of the area of the basin below the sea level, there would commence a deposit of the finer sediment brought down by the rivers. This may well be thought to have been copious considering the character of the country passed through, everywhere composed of the decayed remains of the earlier rocks. Indeed it cannot be doubted that the streams would be turbid with argillaceous matter, and as well known, this would be immediately precipitated upon coming in contact with salt water. Thus the material for the slates of the basin must have steadily accumulated through long ages, producing the strata now existing beneath our city. Borings through them near the hall we now occupy have gone over 2000 feet before reaching other material, though of course the disturbance to which it has been subjected and consequent plications make it doubtful if the actual thickness of the slate deposited was more than 1200 or 1500 feet.

In the meantime disturbances continuing to occur at intervals, and eruptions following, both before and during the consolidation of the strata, it is not to be wondered at that in some localities, after the accumulation of much slate material, portions of the boulders and pebbles should be uplifted over it and so be found above it in our day, or even that upon the broken upturned strata of the slate, conglomerate should be found resting in unconformable position notwithstanding the general condition is that of the latter overlying conformably the former. Moreover, it is altogether likely that whilst the slate was in process of formation the boulders and pebbles of the elevated lands surrounding the basin area may have been carried into it by the wash of the waves at their base, by descent of waters from the adjacent hills or by igneous disturbances leading to the local production of more or less conglomerate upon the slate near the borders of the basin.

As suggested in the beginning of this essay, it was to aid in the solution of the question as to the relative age and position of the rocks of the Boston basin that led my mind to dwell at all upon its probable origin and history. The view I have presented seems to me a reasonable one. If admitted in the main to be correct it must set at rest all question as to which is, as a general fact, the underlying rock, and it likewise determines the deposits of both the conglomerate and slate to have been contemporaneous.

I have no desire to keep from mind the objections that may be brought to such a view. One may be that the quartzites of the ancient formations, pebbles of which are common in the conglomerate, would not have been readily acted upon by the disintegrating action that affected other rocks. This cannot be considered as certain until more is absolutely known than now, not only of the actual character of the atmosphere but of the menstruum that permeated the rocks during the period of the great disintegration. That this menstruum may have been strongly alkaline is not unlikely in view of the extensive decomposition of feldspathic formations, and if so the quartzose strata would suffer decay with the others. The so-called quartzite was then without doubt simply a friable sandstone and possibly contained a considerable admixture of other grains than those of pure quartz, which would help to facilitate its destruction.

That the tendency of a rock of this character to form concretions upon exposure to the elements and other agencies and thus yield spheroidal forms is, I think, demonstrated by observations of Dr. Wadsworth upon the St. Peters and Potsdam sandstones, for record of which see a short but suggestive article by him in vol. 22 of these Proceedings, page 201.

In relation to the rounded and pebbly forms of the quartzite as found in the conglomerate of the Boston basin it can be said that this may have been and probably was largely due to the abrasive action of the waves after subsidence.

In hope of throwing some light on the relative position of the rocks of the basin, I was led to think of their origin, and not believing the boulders and pebbles of the conglomerate to have been the result of water erosion alone I came to the conclusion that they were mainly the unchanged material (I mean unchanged by chemical forces) of the ancient formations existing in the strata that became submerged through igneous action within the area of the basin. This view of the probabilities of the past may be and likely is far from a correct one in all particulars, and yet I think it may be found worthy of consideration.

ON THE ORIGIN OF KAMES.

BY N. S. SHALER.

The various classes of drift-deposits formed during the glacial period afford some of the most puzzling structures with which the geologist has to deal. Some of these deposits are, it is true, quite readily interpreted. The broad sheet of ground moraine that covers the general surface of glaciated countries is clearly the wreckage left by the ice when it melted. The drift terraces that border the sea, the great lakes, and the rivers are the rearranged waste of terminal and ground moraines. The strong, rampart-like ridges of intermingled sand, gravel and boulders, having a general east and west extension, are readily seen to fall into the class of front moraines comparable in a general way to the terminal heaps of the Swiss glaciers. But there still remain two classes of drift-deposit that await interpretation. These are the lenticular hills or drumlins, and the class of gravel deposits known as Kames or Eskers, often called in America Indian ridges. I propose in the following pages to discuss the origin of the last named class of structures.

The structure of Kames is more complicated than that of any other class of glacial deposits; it is a difficult task to gather from their ever varying accidents the general and typical features that characterize them, but it will be necessary, to undertake this task before endeavoring to account for their structure. The greater part of the facts on which I shall have to rest the hypothesis of their origin, which it is the aim of this paper to give, are unknown to any save the special students of glacial geology and often unfamiliar to them — for the reason that normal Kame structures are wanting in a large part of the glaciated regions of the world.

The best opportunities for the study of Kames are to be found along the New England sea coast south of Portland, Maine, for in that region they are the most abundant and present their most characteristic features. As exhibited in this region they present the following phenomena: viz., the observer first remarks that the mass of drift before him has a singularly irregular outline, being warped in the most varied ways; very often this warping takes the shape of a great number of irregular hills enclosing depressions between their adjacent bases. These hillocks vary from six to fifty feet in height; their sides are remarkedly steep, often presenting declivities of from twenty to thirty degrees of slope. Generally these hillocks are crowded together on a terraced drift deposit, such as commonly borders the New England sea shore. There may be cases where Kames exist away from these terraced drift deposits, but I have not been able to find any in such position.

In this district the Kame areas may cover the surface of only a few acres, more usually they occupy a belt of country extending inland in a northwest course for an indefinite distance. Even when the Kames occupy a limited area on the shore the observer will notice that the ridges are elongated in a general north and south course, and that their crests have a linear arrangment in the same shore. When the Kame field is elongated and has a distinct north and south extension of several miles in length the hills become modified into a series of narrow embankment-like elevations which commonly receive the name of Indian ridges. These elevations have a remarkably artificial aspect; it is often difficult to believe that any natural causes could have constructed such rampart-shaped structures. Their unnatural aspect has led to the very general notion that they are the work of the aboriginal races of the country — hence their popular name of Indian roads or ridges.

After some years of desultory study on these singular remains of the glacial period, I became convinced that they would only yield their secret to a careful and systematic inquiry. This demanded for its first step a study of their geographical distribution; then a selection of instances where the remaining conditions could be exactly determined so that the hypothesis that might be applied could be subjected to proper inspection. As regards the geographical distribution of the Kames my inquiry has not been complete enough to give more than general results. Imperfect as these observations are, they have sufficient value to be presented here, for they may serve as the basis of further study.

The New England Kames are most extensively developed along the coast belt of the country; the largest and most continuous lines of this class of structures extend inland from the shore to that part of the country where the subsidence that attended the glacial depression did not bury the surface beneath the sea level. In inland regions which the sea did not reach during the period of depression, the Kame structures are less regular and often confused with the ordinary sheet of glacial drift that covers the surface.

The Kame structures are found throughout New York, but are relatively faint in Ohio, especially on the southern confines of the drift area. Descriptions of other countries show that they are of occasional occurrence in nearly all glacial areas that have been carefully studied. They are rarely seen in Switzerland; a region that is typical in other glacial phenomena.

When distinct Kames occur in regions along the line of glacial submergence they are, so far as my own observations extend, in all cases accompanied by considerable areas of thin drift deposits which by their structure indicate that were formed beneath the surface of water. This association long ago led me to the hypothesis that the ordinary Kames are structures that were made beneath the surface of water-covered regions and that they were accumulated at the points where sub-glacial rivers discharged their streams into the sea or into the temporary lakes that abounded over the land surfaces during the glacial period.

In order to test this hypothesis it was necessary to seek some point where the details of a Kame system could in some way be submitted to criticism. Such an opportunity presented itself to me in a remarkably fine system, as yet undescribed, which lies in one of the broad valleys of the southern Adirondacks in which stands the village of Chesterton, Warren County, New York. This valley is the southward continunation of the basin in which lies Schroon Lake and the upper part of Schroon River. At a point about two miles to the north of Chesterton the Schroon River turns to the eastward and pursues its southward course to the Hudson in another valley parallel to that in which it has its origin. The result is that the Chesterton portion of the Schroon valley opens broadly to the north, while on the south it narrows and rises to a col or divide, which is nearly three hundred feet above the Schroon River and about six miles from where that river turns to enter the valley in which it runs in the southern part of its course. An inspection of the glacial scratches makes it clear that during the closing stages of the last ice period the direction of the glacial stream did not turn to the eastward as the river now does, but pursued its course directly up the valley and over the col at its south end and by that route to the lower portion of the Schroon Valley and thence to Lake George. Where now the small stream in the village of Chesterton flows northward down a tolerably steep slope to join the Schroon River the ice flowed up hill in its southward course. At its northern point the Chesterton Kame is first evident in the swamp that occupies the valley of the southern end of Schroon Lake. It then gradually rises from the level of the swamp, which has evidently accumulated about it to a depth of ten to thirty feet. Where first traceable the ridge is not over twenty feet high. I am not certain that I saw the very northern most part of the Kame for the reason that the swamp was at the time of my examination so wet that it was extremely difficult to explore. There may be parts of the ridge above the level of the swamp for two miles north of the northernmost point examined.

At the northernmost position where the Kame is fully exposed and thence for about six miles near to its southern end it consists of a sharp ridge having a height of from ten to seventy feet and a slope of sides of from twenty to thirty degrees of declivity. The ridge is sharp crested and generally free from boulders on the surface. Its interior is imperfectly exposed, but it is evident that it is generally obscurely and irregularly stratified with the cross-bedding that is so frequently found in Kames.

In about nineteen-twentieths of the distance traversed by this Kame its outlines are as distinct as an ordinary railway embankment or an old earthwork fortification would be. There are in the seven miles of its length about six points where it is distinctly interrupted by breaches of no great breadth; at one of these points it appears to have been cut away by the Chesterton brook, at the other points the ridge seems to have been interrupted in its formation. None of these breaks, except that formed by the Chesterton brook, are more than three or four hundred feet in length. Wherever the ridge of the main Kame deposit becomes smaller or is wanting, we find that other deposits of a similar nature come in upon its sides, though sometimes separated from the main Kame by a valley some hundred feet in width.

Throughout the length of the Kame there is more or less morainal matter of a similar nature near the sides of the valley, at some points this stratified material is ordinary terrace drift; again it takes on the character of low hillocks with kettle-like depressions on their flanks and at their bases, such as are usually found along the New England shore. These lateral deposits are most extensive along the southern flank of the Kame ridge. The total amount of drift matter on these lateral deposits is several times as great as that in the central ridge, but they have nothing like the continuity that gives the central Kame its peculiar aspect.

In following the Chesterton Kame to the southward it rises with the floor of the valley and as a whole increases in magnitude until its base attains an elevation of about two hundred feet above the northermost point where it appears. When it nears the elevation of the col that forms the head of the valley it rapidly becomes reduced in height and the materials are in the main much coarser.

When we arrive within a few hundred feet of the col, and ten or twenty feet below its base, the Kame is reduced to a low irregular ridge of large pebbles, its height not exceeding five feet. The pebbles grow larger until near the col they are generally over six inches in diameter; indicating a considerable current in the water in which they are deposited, a current strong enough to bear away the fine material of the Kame.

The col at the head of the valley is a wide U-shaped gorge of the ordinary glacial type. A horizontal line of the col transverse to the valley about forty feet above the highest point has a length of about a thousand feet. The whole of this summit of the col is destitute of Kame deposits having no other glacial waste upon its floor except large boulders. Immediately on passing the crest and entering on the slope which leads southward from the col we have the most interesting and instructive feature connected with these deposits. On this slope there is evidence that a considerable river flowed over the col; from the crest of the divide a channel which will average fifteen feet in depth and about fifty feet in width extends downwards in a southerly direction towards the base of the valley. This gorge is most plainly water worn and generally larger than beds of the mountain streams of this county where they descend steep slopes. It is sufficient in size to accommodate the average flow of the Schroon River. At present this gorge is not the seat of any stream. In ordinary seasons there is not water enough passing through it to keep the vegetation from covering its beds. No one can see it and doubt that at a very recent time there was a very large brook flowing through its bed, and that the only possible way in which such a stream could come to occupy this place would be by filling the Chesterton valley with a glacier, from beneath which emerged the vanished river.

With this chain of evidence it is possible to reconstruct the history of the Chesterton Kames. This history seems to me to have been as follows: —

During the closing stages of the last glacial period the ice sheet in its retreat northward formed a dam in this Chesterton valley, creating a lake from which a large stream flowed over the above mentioned col. As the ice retreated to the northward it left in the floor of the valley the waste brought into the lake by the subglacial streams. This waste ejected from the retreating submerged arch of the glacial stream fell near its exit from beneath the ice and formed the Indian ridge or continuous Kame. For most of the time while this lake-forming glacier was retreating to the northward the subglacial stream debouched near the centre of the valley; from time to time accidents caused the exit of the stream to change its position when the building of the central Kame was interrupted and the lateral deposits formed. For a large part of the time while the ice was retreating there were streams breaking out on the borders of the ice sheet that formed the deposits on the flanks of the valley. Finally, when the ice stream in the main valley of the Schroon River disappeared, this lake was drained away, leaving the region much as we now find it.

That this was the general succession of events in the formation of these Kames does not, it seems to me, admit of a question. There are however some particular points on which there may well be doubt. The distinct central Kame may not have been altogether deposited in the open water, but may have been partly formed within the arch at the end of the glacier and bared as this arch progressively retreated; it may, perhaps, owe its extreme sharpness and regularity of form to this cause; although it seems to me that it would have been possible to form it in the open water. The lateral deposits of table and ridge drift may be in some part due to the washing of glacial waste from the steep hill-sides into the border of the lake rather than to any lateral streams, as before suggested, but the main conclusion that the central ridge and the other Kames were formed beneath a sheet of water by the retreating ice at the close of the glacial period seems thoroughly proven. The extreme regularity of the ridge, the absence of any evidence that portions of it were bodily thrust forward by the advancing ice are conclusive evidence that the progress of retreat of the glacier must have been singularly measured and uniform in its action; any readvance would have led to the crumpling of the ridge into a confused mass; any sudden retreat would have left long breaks in the deposit. All the evidence goes to show that the process of retreat was carried on with singular uniformity.

There are evidences of similar glacial lakes in other parts of the southern Adirondacks, but these do not as far as I have been able to find, exhibit the important facts proved by that of Chesterton. One of these Kame hills lies in and about the village of Warren, a few miles north of Chester. At that point it is clear that for a time the drainage that now goes to the Hudson was turned to the eastward over the col and down the ravine in which lies the turnpike that leads to Lake George — this point demands a more careful study than I have been able to give to it.

If, with the result of the study of the Chesterton Kame in mind, we turn to the sea-shore structures of this nature we perceive that they are more easily interpretable by means of the clue which we have obtained in this mountain region. We readily perceive that the presence of these Kames in the shore district of New England is explained by the fact that the subglacial streams would certainly find their way to the sea along this ice front. The general limitation of the Kames to the shore-belt which was below the level of the post glacial submergence is explainable from the fact that it requires the submergence of the exits of the under ice streams to give the conditions for the formation of Kame ridges. When these discharge points of the subglacial streams are above the drainage, the materials thrown out have a much more irregular distribution, they are more scattered, they would generally take on the form of low detrital cones composed of only the coarser part of the glacial waste.

There is further confirmation of this hypothesis in the fact that Kames are generally, if not usually surrounded by terrace drift which is unquestionably the result of water action as before mentioned. I have never found distinct Kame deposits entirely apart from areas of terrace drift. It should be said, however, that these opinions require a careful reviewing in the light of studies made in a great variety of positions before they can be deemed to be fully proven.

In connection with my study of shore Kames I have been led to certain important inferences concerning the rate of elevation of our shores at the close of the glacial submergence. In the first place I must note the fact that the glacial submergence along the southern New England coast was much greater than is commonly assumed. Very distinct cross-bedded sands in extensive sheets occur at points as much as one hundred and seventy feet above high tide in positions where owing to the contour of the ground one cannot believe that they were formed in any inclosed basin of fresh water. As it is not my present object to discuss this question, I will only note the fact that such a deposit occurs at Randolph station on the Old Colony Railway about ninety miles north of Acton at a height of 190 to 200 feet. They are also found in the region about Attleboro at nearly the same height. These deposits were clearly distributed by tidal action and as we must suppose that the water lay to the depth of fifty feet or so above the place of the deposit there must have been something like two hundred feet of depression along this shore where the glacier left it.

Between this level of two hundred feet above the sea and the present shore line the Kames are plentifully scattered, most abundant on the lower one hundred feet of this strip of country, but evident here and there over its whole surface. Now, when we bear in mind the delicate structure of Kames, their sharp outlines, their kettles and Indian ridges, we find difficulty in conceiving how they escaped the cutting action of the sea beach that must have been dragged over all of this surface as it was emerging from the sea. A single month of exposure to such waves as act even in the more sheltered bays of the shore would entirely destroy the more delicate outlines of these gravel heaps. After a careful examination of the evidence I have been driven to suppose that at the close of the glacial period the reëlevation of the land must have been acomplished with a very great suddenness.

The Curator showed two stuffed African monkeys presented to the museum by Miss R. L. Learned. The thanks of the Society were voted to the donor, and also to Mr. Jabez S. Holmes for a spider-crab from the California coast.

GENERAL MEETING, FEBRUARY 20, 1884.

The President, Mr. S. H. Scudder, in the chair. Twenty-eight persons present.

Dr. T. Sterry Hunt discussed the relation of character of the Cambrian rocks in North America, and among other points the recognition of the Ordovician system and the propriety of its name were referred to.

Prof. C. H. Hitchcock pointed out in his geological map of the United States the range of the Ordovician and Cambrian groups, and discussed the Taconic system.

Mr. S. H. Scudder showed with the microscope some washings of the boulder clays from the Chicago water supply, including among other matter specimens of Sporangites, or macrospores.

General Meeting, March 5, 1884.

Ex-President, Mr. T. T. Bouvé, in the chair. Thirty-two persons present.

Mr. Wm. S. Whitwell was elected an Associate Member.

The following paper was read:

LARVAL THEORY OF THE ORIGIN OF CELLULAR TISSUES.

BY ALPHEUS HYATT.

The opinion that the higher animals are complex, colonial aggregates of cells, which in structure are equivalents of the lowest and minutest adult forms of the animal kingdom, the unicellular bodies of Protozoa, has been steadily gaining in probability since it was first announced by Oken in 1805 in "Die Zeugung," Frankfurt bei Wesche, 8vo. This work we have not yet seen, but in the first edition of the Naturphilosophie, Jena 1809, II, XII Buch, Zoogenie, he describes protoplasm as "Punctsubstanz" and as giving rise to the "Blasenform or Zellform" in both animals and plants. Oken considered the lower animals "Polypen, Medusen, Beroen, kurz alle Gallertthiere" to be composed of "Punctsubstanz." The nerves, cartilage, bones of higher animals were considered as modifications of this form of protoplasm, but the skin and fleshy parts including the viscera were described as cellular, "dem Feisch liegt die Bläschenform zur grunde," again on p. 30, "die Eingeweide welche am meistens aus Zellengeweb bestehen." Oken in XII, VIII Buch, treats of the subject we are more immediately interested with, and writes as follows; "Pflanzen und Thiere können nur Metamorphosen von Infusorien sein," "im kleinsten sind sie nur infusoriale Bläschen die durch verschiedene Combinationen sich verschieden gestalten und zu höheren Organismen aufwachsen," and also adds on p. 29 in anticipation of one of the points advanced in the following paper, "auch besteht der Samen aller Thiere aus Infusorien."

This author directly compares his cystic or Intestinal animals, Infusoria, with ova and speaks of them as Oozoa, and in the preface to the English edition of his Physiophilosophy, Lond. 1847, Ray Society, he writes that "all organic beings originate from and consist of vesicles or cells." Their production is nothing else than a regular agglomeration of Infusoria; not of course of species previously elaborated or perfect, but of mucous vesicles or points in general which first form themselves by their union or combination into particular species." Oken's view was based on observations of the resemblances existing between the Protozoa and the cells in the tissues of the Metazoa, and it is evident he is entitled to be considered the first teacher of the unicellular doctrine, an honor now universally given to Von Siebold.

Oken's effort to demonstrate the cellular structure of animals and plants preceded the and more accurate work of Schleiden and Schwann in 1838, and he appears, also, to have been the first to recognize fully the essential identity in histological composition and structure of all forms of life.

Von Siebold in his Anatomy of the Invertebrata, 1845, separated the Protozoa from all the higher animals, and accurately defined them as minute forms with slight undifferentiated structures, which were reducible to the type of a single cell. Prof. H. J. Clark took the next step when he produced definite proofs, that the sponges, though multicellular, were transitional forms between the unicellular and multicellular animals, in his essay, Memoirs of the Boston Society of Natural History, vol. I. Before his time the proofs had been in continuation of the line of general observation begun by Oken, and rested upon such comparisons as could be made between the isolated cells of the tissues, and the adult, unicellular zoons[1] of the Protozoa.

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[1] We use the word *Zoon* to replace that of individual or person, and as a parallel term with phyton as used among plants. Individual is an old term with an accepted signification, meaning an organic being which cannot be divided, and, therefore, must be considered as a whole. Person is equally objectionable since it means an individual having a certain character. The personality of God and of man are appropriate expressions. but to speak of the personality of a polyp or a bion conveys no ideas except erroneous ones. *Zoon*, in the sense here used, means any animal form containing the elements of typical structures of the group to which it belongs. Thus a Pro-

The homology of a Protozoon with an isolated cell of the tissues of any of the higher egg-bearing animals, or Metazoa rests upon similarity in structure, and in the mode of performing the essential functions of reproduction and assimilation. There are, however, objections, which throw doubt upon the unicellular character of the higher forms of the Protozoa. There are some which like Actinophrys seem to be made up of cells, and others among Flagellata and Ciliata having internal organs, and certainly a distinct integument, which has a cellular aspect. M. J. Kunstler has written the ablest exposition of such views in an article on Flagellata in Bull. Soc. Zool. de France, 1882, pt. 1.

This author though adhering to the unicellular theory, denies the usual assertion of the simplicity of the cell and adduces many facts in favor of the opinion, that cells in the higher Protoza and among Metazoa are not primitive morphological elements, but may be composed of elementary discs, sarcous elements "spherules protoplasmiques." These views are developed from those of Bowman, Milne Edwards and others, and are useful in enabling us to account for the structures of the muscles in the higher animals and seem also to be applicable to the explanation of the differentiated integuments and organs of Flagellata and Ciliata.

tozoon is also a unicellular zoon, a Metazoon also a multicellular zoon. The typical sponge as we have defined it above is a Spongozoon. This use of a new word enables us to avoid the confusion of Huxley, who allowed himself to be bound by the old term and its common usage. He, therefore, was forced to regard the individual among animals as including, "the whole product of one egg," a definition admirably adapted to man and single animals but inadmissible for the cycles of the invertebrates. This term cannot express the cycle of hydra, colony, gonophore, or medusa, the latter both males and females, and when separate capable of exercising all the functions and completely filling out the conventional idea of individuality. By using this new term on the other hand the hydra may be conveniently designated as a Hydrozoon, the colony a colony of Hydrozoons, the gonophore, or fully developed Medusa, and the bud or egg, also Hydrozoons, in whatever shape they may appear. The egg is a zoon of the simplest form and while still a single cell homologous with a Protozoon becoming a Metazoon as soon as its character as a mass of tissue building zoons is apparent. The use of the word individual also involves us in curious dilemmas, thus a Protozoon is an individual but its homologue the single cell cannot be expressed by the same term and certainly the attempt to stretch it in order to accomodate a colony as above described, on the ground of the inseparability of the different forms, would oblige us logically to call the whole biological cycle an individual. Metaphysically this may be correct, but it neglects all morphological and definite boundaries in the use of terminology, and is putting new wine into old bottles without regard to the possible consequence.

The author finds the integuments in Flagellata to consist of at least four distinct layers, some of these layers having a curiously close resemblance to cellular tissues as every investigator who has seen them can also testify. He has, however, tried to demonstrate a true alimentary canal with large, perhaps respiratory oesophagus, an anal or intestinal extremity which opens externally at the posterior pole of the body, specialized reproductive organs, and a water system, and has delineated the production of germs from the nucleus in a special reproductive tube in Heteromitus, a biflagellate form. It is probable, that the young he observed in the oviducts, like those described by authors in Vorticella, and other Protozoa were parasites, and it is difficult to credit the existence of some of these organs in the Flagellata, when almost all observers unite in asserting, that with the exception of the stomach pouch, intestine and anus, the pulsating vesicle, and the nucleus and so-called nucleolus, there are no other organs even in the highest of the Ciliata, and also that the integument or ectosarc is a simple layer differing only very slightly from and really forming a continuation of the endosarc.

Huxley's observations made with the view of testing the unicellular nature of Protozoa in Jour. Linn. Soc. 1876. p. 203, sustain Oken's opinion and Von Siebold's definition.

Claus, Grundzüge der Zoologie, after giving the best summary we have yet seen of the evidence upon these points, concludes as follows, in the words of Haeckel, " der Infusorienlieb bietet demnach einen Complex von Differenzirungen, die wir einseln als Attribute echter Zellen auftreten sehn." " The body of the Infusorian (alluding exclusively to the Ciliata) offers, therefore, a collective assemblage of differentiations, which we see appearing separately as attributes of true cells " (among the Metazoa.) This conclusion is sustained by the general morphology of the cell, the late brilliant discoveries of Metschnikoff upon resorption and intra cellular digestion, the habits of wandering cells and white-blood corpuscles and the structure of some eggs. For example, the structure of the eggs of Insects and the origin of the blastoderm from true amoeba-like cells which originate either in the vitellus or directly from division of the nucleus. Authors differ on this last question, but not on the others, and have concurred in Weissmann's discovery, Zeit. Wiss. Zool. vol.

13, 1863.[1] A very clear and convincing series of observations with figures has just appeared (Mem. Bost. Soc. Nat. Hist., vol. III, no. 8, Development of Oecanthus and Teleas, p. 236, 1884) showing that the blastoderm is formed from amoeboid cells, which look and act like these animals and assimilate the yolk cells among which they first arise. The tissues of the Metazoa were, therefore, either derived from Amoeboid forms or from these indirectly through the Flagellata and Ciliata.

The presence of collars and flagella, the internal structure of the cells of the ectoderm in the larvae of Silicea and Keratosa and some Calcarea, the reappearance of these cells throughout the interior of the lower Calcarea, and more localized in the ampullaceous sacs of the remaining sponges, and the universality and importance of intra-cellular digestion as carried on by these cells in the sponges, — these are strong morphological and physiological arguments for the immediate derivation of the sponges from the Protozoa Flagellata. These lose none of their force from the prevalence of flagellate cells in the tissues of other and higher animals as in Hydra, Actinozoa, etc.; the fact remains that the sponges are mainly, perhaps wholly, dependent upon intra-cellular digestion, and that the whole organization is a sieve with a gastro-vascular water system adapted in the most direct manner to the efficient performance of this function. As we shall also try to show, the embryo is entirely peculiar in development as compared with other allied types, and gives good ground for the opinion, that the Porifera are not degraded forms of Metazoa, but a normal progressive type on the lower borders of the Metazoa and still retaining some of the primitive characteristics and histological structure of the transitional types of the colonial Protozoa Flagellata.

This conclusion, however, is not so secure as one at first imagines. It is perfectly well known that similar forms, structures, and organs appear and reappear in different groups of the same stock, while these forms, structures and organs could not possibly have been derived by inheritance from the common stock, which did not have them. They must have arisen independently in each of the different branches of the same common stock as parallelisms. The history of modern classification is mainly a series of rectifications of the mistakes made by the older naturalists in associating animals of the same stock but of different genetic groups, because they were misled by these purely representative and genetically disconnected parallelisms. The separation of the branch of the Articulata into numerous types, and the new classifications of the Crustacea, the association of the Fishes and Batrachians in one type and of Reptiles and Birds in another, are good illustrations of this remark, as well as the researches of Wurtemburger and the author upon fossil Cephalopoda, Cope upon Batrachians and Reptiles, Marsh and Gaudry upon Mammalia. There is we think just as much evidence for the view that the Metazoa sprang by gradations yet to be discovered from the compound colonial amoeboid Protozoa, as there is that they came directly from colonial forms of the Flagellata or Ciliata. Bütschli's late discoveries seem to be turning the scale in favor of the latter hypothesis, but, even these are still insufficient to fill the gap between the Metazoa and the Flagellata.

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[1] The best summary of this subject with new observations is given by Bobretsky, Zeitschr. wissensch. Zool., vol. XXXI, p. 195, 1878.

In the Biologisches Centralblatt, March 1884, vol. IV, no. 1, p. 5, he points out among the Flagellata, that Eudorina has male and female colonies of zoons. The male colony gives birth by self-division to a second series of colonies, which eventually unite with the female zoons of the female colonies and fecundate them. These secondary colonies of male zoons, he calls on account of their peculiar forms and offices, the "Spermatozoonplatten der Eudorina." In Volvox globator separate sexual colonies are not produced, but in this well-known globular form with its numerous flagellate zoons, certain of these become differentiated into males, and others into females. The male zoons become, through successive divisions, reduced to Spermatozoonplatten like those of Eudorina and these then conjugate with and fertilize the female zoons. In this form we are, therefore, thanks to Bütschli, made acquainted with a true colony, consisting of a number of associated zoons, which has arisen like tissue in the egg by division from one cell, and in which also, as in Metazoa, cells or zoons become differentiated into males and females. This comparison is also still farther carried out by the fact, that the males undergo, as do spermatocysts, spontaneous division and thus produce active fertilizing elements, or spermatozoa; while the females, like eggs in the higher animals, remain less differentiated, or arrested in development and larger in size, and await contact with the male before becoming strong enough for reproduction by division. As Bütschli states it, " nicht nur die männliche Gamete, sondern auch die weibliche durch eine Reihe fortgesetzer Theilungen aus einer gewöhnlichen Zelle hervorgeht. Nur zeigt sich hierbei die Tendenz, die Zahl der Theilungen, welche zu den weiblichen Gameten führen, zu verringern, so dass diese letztern allmählich eine beträchtlichere Grösse darbieten, wie die männlichen."

We find among the Ciliata as demonstrated by several authors, that many highly developed genera like Paramecium are true hermaphrodites, and after conjugation separate as before, and we also find true secondary males, as in Vorticella, and the like, which pass entirely into the body of the female. It is quite probable that these cases in which conjugation by absorption occurs in Protozoa will be eventually explained as true sexual union equivalent to fecundation by spermatozoa, whereas the conjugation without absorption of the male form would necessarily occur only between hermaphrodites which had not entered upon so high a state of sexual differentiation, and belongs simply to the phenomena of fertilization by crossing.

This is very near the same view as that taken by Engelmann (Morph. Jahrb. I, p. 630) but differs in homologizing his Microgonid or small male with a spermatozoon, and his Macrogonid or large female, with an egg, thus following out and applying the terminology of Bütschli to the phenomena of conjugation among Protozoa.

Balbiani (Journ. de Micrographie, no. 8, 1882, p. 378) lays great stress upon the fact that it is the whole animal among the Protozoa, which acts both as an egg and as a spermatozoon, and that sexual differentiation takes place in the central germinative mass of the body or cell, the nucleus becoming the female element, and the nucleolus the male. He concludes, that a close comparison can be made between the discovery of the resorption or disappearance of a portion of the nucleus, which takes place after conjugation in Paramecium bursaria, and the expulsion of the polar globules in the egg of Metazoa, and that a true female pronucleus is formed, remaining in the individual after the resorption or exclusion of the unnecessary part of the nucleus, and finally, that the striated spindle-shaped bodies of the nucleolus become united with the female pronucleus forming a new nucleus. "There is, therefore," according to this author, "no difficulty in comparing the conjugation of Infusoria with the fecundation of the egg."

This author originated the opinion, that as in the egg among Metazoa, the effect of conjugation among the Protozoa is the inauguration of a period of intensified reproduction by self-division. He thus made another comparison between the effects of fecundation in the egg, and those of conjugation in unicellular animals. He here abandons the opinion formerly held that the nucleolus is a sperm-producing, and the nucleus an egg-producing, organ among Protozoa, and takes up the same view, so far as the bisexual nature of the nucleus is concerned, as has been taken by Hertwig, and Engelmann.

Bütschli has really done more than any other author in his extended comparisons of the phenomena attending fecundation in the eggs of Metazoa, and conjugation in the bodies of Protozoa Ciliata. In Abh. Senck. nat. Geselsch. vol. x, 1876, he shows the essential morphological similarity of these processes, and also extends the comparison to the division of cells in the Metazoa, showing that as in the Infusoria the division of the nuclei which precedes segmentation of the cell is accompanied by the formation of a connective or direction spindle, and that the plane of division passes through the transverse differentiated zone of the direction spindle in all cases whether in eggs, blood corpuscles, spermatocysts or bodies of the Infusoria.

This author regards the so-called nucleolus of Protozoa as differentiated from the nucleus and compares the disappearence of parts of the old nucleus after conjugation with the ejection of the polar vesicles from the egg. In his view the nucleolus is really the active agent of fertilization in conjugation and the nucleus is the passive pórtion of which parts disappear during this process. He, however, denies that the nucleolus alone is exchanged especially in the conjugation of Vorticella.

The transformation of the neucleoli of Protozoa into spindle-shaped striated bodies which act more or less in concert with the products of the division of the nuclei or secondary nuclei, remind us forcibly of the different spindles which appear during the development and segmentation of the egg. But this has not been fully traced out, and we do not know what the morphological resemblance signifies, farther than that it indicates identity between the products of the primitive sexual segmentation of nuclei in Protozoa and the agamic segmentation of the same part in Metazoa.

Engelmann (Morph. Jahrb. I, 1876, p. 628) unites with Bütschli in the opinion that the nucleus and nucleolus are products of one and the same body, the primitive nucleus, that they have different sexual functions in the Protozoa, and in their united form are strictly homologous, functionally and structurally, with the nucleus of the ovum. This author, however, considers the nucleolus as being probably devoted to the purely male function of being interchanged during copulation. This seems probable, since in many forms after conjugation the nucleolus disappears, apparently becoming united with the nucleus, and only reappears again just before the breeding period, apparently arising from division of the homogeneous nucleus.

Bütschli, in one of his last articles, contends that there is no elimination of male or female elements during conjugation in the nucleus of the Protozoa, and that the bisexual character of the nucleus cannot be assumed on this ground. He also thinks that the assumption of bisexuality for the ovum is not accordant with the phenomena of parthenogenesis among plants and possibly among animals.

Dr. Whitman gives a résumé of Bütschli's, Engelmann's and Hertwig's views on the bisexuality of the nucleus, and evidently does not regard Bütschli's objections as very strong. In fact it is very difficult to account for the differentiation of the nucleus and spindle bodies (nucleoli) in Protozoa and the difference of structure admitted by Bütschli, by any other supposition, than that they are the first sign of sexual distinction arising by differentiation from the sexless, homogeneous nucleus.

Hertwig appears to have been the first to show that the fecundation of the egg was accomplished by the union of the male pronucleus formed from the spermatozoon after its passage into the egg, and the female pronucleus, that part of the nucleus which remains in the egg after exclusion of the polar globules, (Morph. Jahrb. 1876), thus conclusively proving that the resulting or renovated nucleus was bisexual or married, so far as known, in all eggs. This point certainly tells strongly in favor of the view that the duplex or married character of the segmentation nucleus is an essential preliminary condition for extensive growth by self-division.

We propose, therefore, for convenience sake, to call the original undifferentiated generative body the nucleus, and its products respectively the male or masculonucleus, and the female or feminonucleus, reserving the name of spermatozoa and polar globules for the products of the division of the masculonucleus; and the name of maritonucleus or married nucleus for the renovated nucleus of the egg after its union with the male pronucleus. This last we shall also more appropriately term the spermonucleus in accordance with its derivation.

Dr. C. S. Minot was the first to assume that ova and spermatocysts were essentially bisexual. This author explained the casting off of the polar globules from the egg previous to segmentation, and the residuum, or undivided nuclear mass left in the centre, and the parallel case of the production of spermatozoa in the spermatozocyst and the undivided mass left in the centre of the cysts, by means of the Gonoblast theory (Proc. Bost. Soc. Nat. Hist., Nov. 1877, p. 170).[1] According to this hypothesis the residuum of the spermatocyst is the unused female elements of the bisexual nucleus, equivalent to the active feminonucleus of the egg, while the active spermatozoa are the products of the division of the masculonucleus and are the homologues of the inactive and useless polar globules in the egg. Thus the part useless and resorbed in the male spermatocyst corresponds to the active part of the female ovum, while the active part of the male on the other hand corresponds to the inactive and discarded parts of the ovum. The products of the nucleus, masculonucleus and feminonucleus, are thus explained as being in every situation complementary to each other. This theory is consistent, and we do not see how those who consider the double nucleus of Protozoa as bisexual can avoid adopting it, especially, if they agree with Bütschli, that portions of the nucleus are unnecessary and are resorbed or ejected after conjugation.

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[1] See also Am. Nat., Feb. 1880; and Biol. Centralblatt, 1882, p. 365.

Balfour (Ann. and Mag. Nat. Hist.) 1878, subsequently but independently of Minot's publication, rediscovered the same mode of explanation, but his exposition is not so comprehensive as Dr. Minot's, especially with regard to the spermatocysts.

Balfour, Whitman, and Mark all insist that the polar globules are entirely independent of fecundation, and this is evidently true since as a rule the first polar vesicle appears before impregnation, and invariably no connection takes place between the spermonucleus and the feminonucleus beforehand. The history of the early stages of the spindle and the archamphiasters shows their agamic origin especially in those types in which, as in Hydra, Asterias and Echinus, they may be developed before impregnation occurs. Bütschli, Fol, and Hertwig, according to Mark, have satisfied themselves that polar globules may be produced in unfertilized eggs (Bul. Mus., Comp. Zool. vol. VI, pt. 12, p. 449), and Ryder quotes similar opinion of C. K. Hoffman derived from the study of fishes.

Ryder takes the ground that the formation of polar globules in Ostrea is dependent upon impregnation because they are never formed until after the spermatozoon enters the egg. (Embryog. Osseous Fishes, No. 5, Impreg. of egg, p. 20.) This author, however, clearly states that it is the vitellus which is entered by the spermatozoon, and does not say that the masculonucleus or the feminonucleus comes in contact with the spermonucleus before the globules are formed. Causal connection between the act of impregnation and the formation of the globules is, therefore, improbable, since there is no such invariable sequence as is found between the formation of the maritonucleus and the subsequent segmentation of the ovum.

A similar case is given by Dr. H. W. Conn in his life history of Thalassema (Biol. Labr. John Hopkins Univ. vol. III, no. 1, 1884, p. 31.) The first polar globule arises in this form always after impregnation, and the description of the rhythmic periods of activity and rest which accompany and follow the formation of the polar globules is very graphic, and render the author's comparison of the mode of formation of these bodies and the primary segmentation of the egg after the maritonucleus is formed exceedingly clear. Here again, however, the fact of a sequence in the phenomena is unsustained by the morphological evidence of direct union, and stress is laid upon the mere succession, which as in the case of Ostrea might be considered as a reversion, or as an acquired peculiarity of this form.

These examples are also important in another sense, since they, as now understood, are directly opposed to the theory advocated, farther on, that the agamic occurrence of polar globules in Metazoa may be explained by the law of concentration and acceleration in development.

The absence of distinct polar vesicles in several isolated instances as well as generally in the Arthropoda and Rotifera is noted by Balfour, Mark and others. Prof. Mark (Bull. Mus. Comp. Zool. vol. VI, p. 548), is disposed to favor the views of the universality of the formation of polar globules as homologous processes. "There seems to be little doubt that the elimination of portions of the substance of the germinative vesicle as described by Balfour for Elasmobranchs, by Oellacher for bony fishes and birds, and by Van Bembeke and Hertwig for Amphibia represents in some hitherto unexplained manner the formation of polar globules." According to Ryder (Embryog. Osseous Fishes), a slight prominence arises on the germinative membrane opposite the micropyle in the egg of the Cod, which, though uncertain, is possibly the homologue of the polar vesicle. The polar globules have not been found in the Sponges though no direct search has as yet been made which would justify one in assuming that they may be absent in this group, and we know very little about the earliest stages of the ova, during and immediately preceding impregnation.

Parthenogenetic development of eggs taking place after the expulsion of the polar globules does not seem to be explicable upon a gonoblastic basis, and would appear to tell against any theory of the essential nature of the processes of fecundation. If true, it indicates the primitively agamic nature of all phenomena of growth by segmentation and thus reduces the act of impregnation to a secondary or acquired habit arising from the differentiation of the sexes.

Balfour quotes the researches of Bütschli, Strasburger and Hertwig in support of his view of the polar globules, and then suggests in his Comp. Embryol. vol. I, p. 62, that the capacity for parthenogenetic development may be dependent upon the expulsion of the polar globules, and adds that "strong support for this hypothesis would be afforded were it definitely established that polar bodies were not formed in the Arthropoda and Rotifera," which are extensively parthenogenetic.

The apparent contradictions to the gonoblastic theory which may be found in the absence of true polar globules in the forms mentioned and in others, are not, as often supposed, fatal to the hypothesis. If it be true, that the nuclei become differentiated, in spermatocysts and ova and in the bodies of Protozoa, into two parts which may be properly termed masculo- and feminonuclei, and, if these parts have distinct sexual functions, so that the union of the products of the masculonuclei of spermatocysts with the feminonuclei of ova is necessary in order to form segmentation or maritonuclei, the gonoblast theory is reliable, otherwise it fails. What may become of the useless or superfluous feminonuclei of the spermatocysts or the equally useless masculonuclei of the ova is evidently not vital to the explanation, nor is it essential, as we claim, that the expulsion of the polar globules should as a rule take place earlier in the Metazoa than the resorption or exclusion of the useless parts of the nucleus in the Protozoa. We have in other publications tried to give the evidence with regard to the law of earlier inheritance and think it should be applicable to such phenomena, if it has the wide application which has been claimed for it, but it is not a necessity of the gonoblastic theory.

This law certainly seems to give a plausible answer to such objections to the gonoblastic theory as have been made by Dr. Whitman in his review of this theory in his paper on the embryology of Clepsine (Quart. Journ. Micr. Sci. n. s., vol. XVIII, 1878.) This author regards the agamic nature of the origin of the polar globules as contrary to the hypothesis, whereas if we are right in our translation of the laws of heredity the reverse is true and since the Metazoa are descendants of Protozoa the globules should tend to appear earlier or previous to impregnation in the ova. We are aware that this is setting up one hypothesis to support another, but it will be remembered we hope by just critics, that the law of acceleration and concentration in development is not an untested discovery, and it appears to us to be shown more or less in all the types of the animal kingdom except the Protozoa, which we have not as yet studied with the view of finding examples of its action.

Dr. Mark in his work on the Maturation etc. of the Egg in Limax campestris (Bull. Mus. Comp. Zool. vol. VI, No. 12, pt. 2), gives considerable attention to the bisexual theory. He also thinks that the formation of the globules is not connected with sexual phenomena at all, but belongs to the processes of agamic cell segmentation as stated by Hertwig, and others, and lately by H. W. Conn, and therefore differs radically from the casting off or resorption of nuclear parts after fecundation in Protozoa.

Fleming declares, without reserve, his belief in the homologous nature of all the transformations of the nuclei and cell division in the cells of plants, animals, and in ova (Beitr. z. Kenntn. d. Zelle etc., Archiv. Mik. Anat. 1882), while Strassburger (ueber Theil. d. Zelle p. 584 in the same periodical), admits more variability in in the transformations of the nuclei, but describes only two modes of division, the indirect and direct, which he considers as not radically differing but correllative processes, one pathological and the other the healthy normal mode. These general results confirm the position formerly taken by Bütschli of the homologous nature of these transformations throughout the animal kingdom, though Fleming considers it necessary to deny that they have necessarily any genetic significiance.

That the processes of nuclear division may be incomplete stages in the formation of cells may, therefore, be provisionally assumed; and the conclusion that a purely sexual result in the Protozoa may become either partly or wholly agamic in the Metazoa seems to us from our experience in other departments of research, as we have said above, to be a natural and even a probable result. That the globules may be cells thrown off in some forms, and in others become merely swollen prominences of the ovum which are not cast off and possibly resorbed into the vitellus, or in others purely useless nuclear parts which are resorbed, appear to show stages of differentiation in the same process of cell division, which sometimes results in the formation of separate cells and at other times is abortive.

Bütschli has shown that spermatozoa are probably products of the spontaneous division of cells. According to the extensive researches of La Valette St. George the mother cell or spermatocyst is apt to divide into two parts, one of which eventually subdivides into spermatozoa, and the other is left in the cyst. This cystenkern or feminonucleus is a useless residuum of protoplasm in most forms, and occupies a more or less central position with purely passive functions. It is certainly very interesting in this connection to note Fleming's discovery, that spermatozoa and nuclei of ova consist of two substances, one readily stainable, and one staining with difficulty chromatic and achromatic. He admits the existence of the spermonucleus and its marriage with the feminonucleus in Echinoderms, describes the loss of the tail which is composed of achromatic protoplasm, but considers that the feminonucleus of the ovum has a similar constitution or is composed of stainable matter like the spermonucleus. If this were unquestionable, the gonoblastic theory would be seriously shaken. Fleming's figures, however, show decided morphological differences between the spermonucleus and feminonucleus of the ova (Archiv. Micr. Anat. 1882), and this leads to doubts as to the true import of his chromatic and achromatic substances, and whether they can be considered as tests of morphological as well as physiological differences or similarities. The researches of Frommann (Struk. Lebenser. und Reakt. thiers. und pflanz. Zellen, Jena. Zeitschr. vol. XVII, n. f., Bd. X, and separate publication, Jena, 1884), have shown that the cell passes through a series of metamorphoses, and has a life history during which the nucleus arises by differentiation out of a primitive mass or layer which is at first structureless and homogeneous, and is surrounded by granules and a layer of protoplasm which he styles the hyaloplasma. Frommann's researches do not sustain Fleming's discovery; and Dr. Arnold Brass (Zool. Anzeig. Dec. 1883, p. 681) after studies made upon living cells, in this respect resembling those of Frommann, declares, that the chromatic substance is reserve food-material, which largely disappears when cells are starved. This material is not, therefore, according to Brass, absolutely essential or even necessarily living matter, whereas achromatic plasma is regarded as the essential living matter of the cell.

Polaejeff (Sitz. d. Akad. Vienna, vol. LXXXVI, 1882), derives the spermatozoa wholly from the division of the nucleus, and does not admit the presence of a protoplasmic residuum in the cyst of Porifera. Polæjeff's remarks seem very clear and specific but there is great room for error in such observations and they need confirmation, since they are opposed to the general results of La Valette St. George and others. Certainly one matured cyst with fully formed spermatozoa, which we have seen, contained two round bodies, apparantly masses of protoplasm, and several times larger than the fully grown active spermatozoa, which lined the cyst. The two cell-like bodies occured on one side and in the lower part of the cyst, which was surrounded by a special envelope having a round opening at the top, similar to the micropyle in the chorion of the ovum. This body could not have been an ampullaceous sac, since it was as large as a larval form found in the same colony; and the wriggling motion of the spermatozoa with their heads against the envelope, forming a layer of closely set rounded granules, left no room for the supposition that they were parasites. It was found with one other specimen in Chalinula limbata at Eastport.

Dr. T. Eimer (Arch. Micr. Anat. 1872, vol. VIII, p. 290), in his article on the development of the Spermatozoa among sponges, states that the results of his researches confirm the opinion that these arise from the nucleus, "und zwar scheint der Kopf aus dem Kern sich zu bilden, während der Faden aus dem Protoplasma der Zelle entsteht." Schultze's figure of the spermatocyst of Halisarca lobularis gives the cells of the chorion or cyst clearly (Zeitschr. Wiss. Zool. vol. XXVIII, pl. 3, f. 18.). In Aplysilla sulfurea (ibid, vol. XXX, pl. 23, f. 20), several spermatocysts in different stages are represented, and in separate figures, the spermatozoa (pl. 24 f. 28) exhibit distinct nuclei, one dark refractile and the other lighter colored near the tail. Spongelia pallescens (ibid vol. XXXII, pl. 8, f. 12), Hircinia spinulosa (ibid, vol. XXXIII, pl. 3, f. 4), and all of the above exhibit no signs of protoplasmic residuum, and appear to confirm Polaejeff's conclusion that there is no cystenkern in the cyst. Schultze, however, did not see the early stages or search for a residual mass and this leaves the evidence in an incomplete condition. Polaejeff in Rep. on Calcarea, reiterates his conclusions, and tries to show, that the spermatocyst in Calcarea has a peculiar covering different from that demonstrated by Schultze in Halisarca previously. He mentions and figures this body in Leucoselenia poterium pl. 3, f. 2, among the Ascones, in Leucilla uter, pl. 6, f. 2f, and writes that he has seen and studied it in most species of Sycones. Polaejeff in his first paper considers that the primitive nucleus in the cell which gives rise to the spermatocyst divides into two parts, one of which becomes by division the spermatocyst or "Ursamenzelle," and the other is transformed into a "Deckzelle." This Deckzelle or cover-cell has many nuclei and spreads around the cyst and forms the envelope, which he considers to spring from it. Schultze compares the covering membrane in Halisarca lobularis with that of the egg, and we have still farther carried out this comparison by finding in Chalinula a distinct opening similar to the micropyle which probably marked the site of some former attachment to the mesoderm. Polaejeff makes an apparently strong objection to the gonoblastic theory founded on the cover-cell. We think this may possibly be explained as an optical error, due to the way in which the specimen was viewed and that no such cell really exists. We suggest this without disrespect for the unquestionably superior character of Polaejeff's work, first because we have a drawing of the ovum of Suberites in which the micropyle seen from the side has exactly the aspect of the cover-cell in the figure of the spermatocyst of Leucilla uter (Rep. Chall. pl. 6, f. 2f), but no granules are shown ; and second, because in our observation on the spermatocyst we looked from above directly down and into the interior of the spermatocyst without seeing any nuclei or granules. If there is not a covering-cell, it is probable that the spermatozoa are really developed out of the peripheral nucleus itself, and that the internal nucleus does not help in forming their bodies, whatever their office may be in other respects.

Polaejeff's farther objections to the gonoblastic theory rest upon several cases in which the spermatozoa appear to arise from the protoplasm of the cyst and not from the nucleus. Bergh, (Vidensk. Medd. Naturk. Foren. Copenhagen, Aarene 1877-78, p. 192, pl. 3), describes and figures the spermatozoa as arising out of the protoplasm of the cyst separated from the nucleus. Kleinenberg, however, saw the first stages in the development of the spermatocyst of Hydra and figures these in his work on Hydra.

(Leipsig, 1872.) The nucleus of his "hodenzell" becomes divided into several nuclei, which becomes less perceptible and are then succeeded by 1 to 4 refractile bodies, which Kleinenberg could not state positively to be derived from the first nuclei. Then the contents were transformed into a transparent mass with a nucleus, and this stage is the first stage depicted by Bergh. This observer figures and describes the Spermatozoa arising in the clear plasma of this cyst, and not in connection with the nucleus. This nucleus is, however, as shown by Kleinenberg, a secondary product of the division of the primitive nucleus, and it seems highly probable that the clear plasma is filled by similar though possibly invisible secondary nuclei from which the spermatozoa are developed. Even, if they had really disappeared in the hyaloplasma, this is not primitive matter, but is a differentiated product more or less due to the masculonuclei and it alone gives rise to spermatozoa. Allman's statement, that the spermatozoa arise from the nuclei in Hydrozoa is specific (Monog. Hydr. 1, 1871, p. 65.). It is probable that all the cases in which the bodies of spermatozoa appear suddenly in clear plasma may be finally accounted for by means of transparent nuclei. The discrepancy which is supposed to exist in different animals as to the stage in which the spermatozoa are generated, is hardly consistent with the general agreement which is manifested in the first stage, during which in all types the division of the primitive nucleus occurs.

Kölliker's studies upon the eggs of Mammalia, birds and Batrachia show that only a portion of the contents of the cyst are used to form the heads of the spermatozoa, and that they are nuclear in origin (Zeitschr. Wiss. Zool. vol. VII, 1856, pl. 13.). Bloomfield (Journ. Micr. Sci. vol. xx, 1880) has recorded the partial division of the contents of the spermatocyst in several worms, mollusks, batrachians and in the mouse, but seems to consider that the division of the nucleus is not a preliminary or necessary stage. His words are as follows: "it appears probable from my investigations on Lumbricus, Tubifex, Hirudo, Helix, Arion, Paludina, Rana, Salamandra, and Mus, that the primitive spermatospore always give rise to a passive blastophor and peripheral spermatoblasts, which latter only are directly converted into spermatozoa."

There are so many authors whose works ought to be considered, that the limits of this paper would be far exceeded, if an attempt was made to quote from all of them. It is only essential to note the results of Von la Valette St. George, who more than any other has studied in all branches of the Animal Kingdom, and a few other authors. St. George supports the conclusions of Kölliker (Op. Cit. and Henle Handb. d. Anat. d. Mensch. Bd. IX, p. 356), in his first article in Arch. Micr. Anat. vol. I, p. 407, 1865, saying that he holds, "die Körper oder Köpfe der Samenelemente für umgewandelte Kerne." In his fifth communication he reiterates this statement, adding that he has also verified Henle's discovery, that the tail is developed differently from the body out of the plasma of the cell and not from the nucleus. (ibid, vol. 15, 1878, p. 263.) In the fourth communication (ibid, vol. XII), he, with reference to the Batrachia, gives the description of the division of the Ursamenzelle, or spermatogonia, the erection of a cellular cyst around it by coalescence of the neighboring cells, forming the Samenfollikel, the division of the nucleus into numerous nuclei, the formation of an outer peripheral layer, and an inner portion, the outer being composed of nuclei which are resorbed and with their own surrounding plasma form the "Cystenhaut," which eventually becomes transformed into Spermatocyten or cells, which in turn give rise to Spermatozoa. The inner remaining nuclei together with what remains of the original nucleus form the Cystenkern which takes no part in this process. The author then, p. 820, declares his belief, that though only stated with reference to this one class this appears to embody a general law of development for all animals. The conclusion on p. 821, that the spermatocyst is the homologue of the ovum has also great interest in connection with other parts of this paper. The first discovery of the cystenkern appears to have been due to Remak's work upon the frog. (Mullers Archiv. 1854, p. 253.) Bütschli (Morph. bedeut. d. Richtungsbläschen, Zool. Anzeig. IV, no. 1, 1884), declares himself in accord with Minot's views of the meaning and homology of the Cystenkern of St. George, or the Spermblastophor of Bloomfield with polar globules, but expresses some doubts with regard the minor points of his comparisons. Semper's researches upon the generation and development of spermatozoa were the principal basis upon which Dr. Minot founded his comparisons with the ovum, and having been quoted in his paper need not be reiterated.

There is, however, no "a priori" reason why the femino-nucleus in the spermatocyst after becoming sexually useless should not acquire secondary habits and be either lost, resorbed, or divide and help in forming the tails of the spermatozoa. It would be unfavorable to our position, if these tails were carried into the ovum and were influential in fecundation. The body of the spermatozoon, however, appears to be the part which penetrates the ovum in the forms so far known, and the tails are apparently lost, or resorbed, or used to plug up the micropylar opening.

It is also not essential to Minot's hypothesis, that the nucleus in the most primitive forms should be bisexual, but simply that it should contain elements which are capable of being differentiated into two parts and that these two parts may either have had, or simply acquired during or after separation the distinctive qualities of the peripheral[1] male, and central female nuclei. The elements as they exist in the primitive nucleus may have been, for all that we know, homogeneous; but it is plain from the researches of authors that the primitive differentiation of the nucleus into two parts is the first well-marked appearence of reproductive functions and differences in Protozoa.

We see no difficulty in admitting Whitman's proposition (Embryology of Clepsine), that fecundation is essentially the addition of living active matter, "the fusion of the corresponding parts of two separate individuals;" but we should add, that this is merely another expression for the character of all fecundative processes, viz.: that they are all essentially due to the need of cross fertilization.[2] That a part of the nucleus in one animal should become specialized for the performance of this function and that the similar part of the nucleus of another should be thrown away in order to create a vacancy for it does not seem at all contrary to the self evident truth of the fusion hypothesis, it simply introduces an element of specialization into the processes of fusion.

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[1] These terms were first used by Van Beneden, La Maturation de l' oeuf, Bruxelles, 1875.

[2] We should also find it necessary to substitute the word "complementary" for "corresponding" in Dr. Whitman's sentence quoted above.

We also know from the researches of authors, that the division of the nucleus almost invariably precedes the subdivision of the cell, and that this is also the case among Protozoa. As a preliminary to conjugation, however, we find that division of the nucleus does take place, and also in multinucleated cells, without being necessarily followed by cell division, though it evidently belongs to the segmental class of reproductive phenomena. The probable causal connection here seems to be quite as evident as is that between the segmentation or maritonucleus in the egg and the subsequent self-division of that body. Thus we are entirely at liberty to present the division of the nucleus as a necessary preliminary to the still greater differentiation in which the cell is male or female according to the preponderance of one or the other of the two parts of the nucleus. That any sexual differences in the development of nuclei introduced by change of habit or difference in food could be seized upon by natural selection, and increased until cross fertilization became a necessity, is almost an inevitable conclusion from what we know of the bad effects of interbreeding among the higher animals.

The common accident of fusion between soft-bodied Amoebae, and other Protozoa, would have been the first step leading to the adoption of fusion as an advantageous habit introductory to cross fertilization and resulting in greater reproductive power on the part of the crossed individuals or zoons through the inevitable blending of their nuclei. Any primitive differentiation in a body like the nucleus, whose functions are generally admitted to be essentially reproductive, would naturally be a sexual distinction. The mere division of the nucleus would have been the first step, the next steps must have been the acquisition of different habits, functions, and finally structure, by the divided nuclei. One part of the divided nucleus would necessarily tend to acquire reproductive habits distinct from the other part, and the ultimate result of division into nuclei, however numerous these might be at first, would be the production of only two kinds, male and female. With this differentiation beginning to be established between the different products of the nucleus, and the act of fusion having become advantageous, we can understand how it could be changed into conjugation for reproductive purposes. The advantages of cross fertilization would secure progress in habits and structure until ultimately the differentiation of highly specialized forms of the nuclei would take place and the sexes would become distinguishable in unicellular animals. We can also understand with the assistance of this theory how the universal habit of cross fertilization might gradually have led to the localization of sexual zoons in special parts of colonies, forming primitive sexual organs in different colonies, thus taking the final step towards the separation of the sexes, as they appear among Metazoa,

In his monograph of the Monera (Jena. Zeitschr., vol. IV, also translation Journ. Micr. Sci., vol. IX, 1869), Haeckel describes the frequent occurrence of fusion between two or more of the amoeba-like young of Protomyxa aurantiaca in order to form larger individuals.[1] This author is uncertain whether the habit is a part of the history of development, or is merely accidental, resulting from contact in feeding on the same morsel, etc., but favors the latter supposition. The number of vacuoles, according to Haeckel, appears to indicate the fusion of as many distinct amoeboid forms, and as there are often several vacuoles in the bodies in many groups of Protozoa, it is quite possible that fusion may be more general than is supposed. This is evidently Haeckel's view as may be read in his remarks with regard to Magosphaera (Jena. Zeitschr., vol. VI, p. 18.). Among the Myxomycetes the formation of a plasmodium is considered by Sachs as concrescence, and he at the same time by his description makes it evident, that it is precisely similar to the ordinary agamic fusion of amoeba-like young of Protomyxa, that it is also undoubtedly followed by fructification, and, therefore, must be considered as a step in the direction of true conjugation. The author's words are as follows: "there is absolutely no reason why the coalescence of the Myxamoebae should not be regarded as a form of conjugation." (Text Book of Botany, 2d Eng. Ed., 1882, p. 253.)

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[1] Concresence is common, and many examples can be given among the Porifera, but this is not properly fusion. It is the union of multicellular bodies, and we think the term fusion should be limited to the more intimate blending of cells, or unicellular zoons, the spermonucleus and feminucleus, etc.

In the lowest form of conjugation which appears, in such plants as Spirogyra, described by Sachs and others we find that complete fusion of the cell contents or equal hermaphroditic conjugation takes place, as it does in some Flagellata as shown by Drysdale and Dallinger and others. In the next stage bisexuality appears, the nuclei become differentiated, and there is an exchange between individuals, which may be and probably is partial as supposed by Hertwig and Engelmann, the masculonuclei or peripheral nuclei, being the essential parts of the nucleus, which are transferred from one individual to another. This condition, which is that of unequal hermaphroditic conjugation introduces that in which the male or so-called nucleolar elements become preponderant in certain zoons more than in others, and these zoons in consequence assume characteristics of true males or microgonids such as are described by Bütschli and Engelmann among Protozoa.[1] This is a primitive condition, and yet it has the essential characteristics of the function of impregnation as it occurs thoughout the animal kingdom. We can readily imagine this series with all its attendant phenomena, and consequent differentiation of sex arising from any inequality in the causes affecting the habits of the zoon, which would thus acquire also the more active habits and desires of the male, or the more passive and receptive habits of the female.

The next stage in this line of morphogenesis would lead into Metazoa where rapid growth and concentrated development would build up tissue in place of loose aggregations of cells and lead us on through a maze of lost or yet undiscovered specializations until we came to creatures like sponges, with perfect male and female cells, but these not so fully localized in the tissues as among the higher Metazoa, and the embryo and cells of the membranes retaining many of the essential characteristics and functions of the zoons in colonies of Protozoa.

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[1] We have found, also after farther examination of the literature, that Ferdinand Cohn in Comptes Rendus, Dec. 1856, p. 1054, and in notice of same (Ann. Mag. Nat. Hist. ser. 2, vol. XIX, 1857, p. 187), has described male and female cells in Volvox, and also the division of the male cells into "spermatozooids." Also the mode of fertillization of the females by the spermatozooids through impenetration, and union with nuclei within. He has also described the greater size of the females, which is a notable point in Bütschli's comparisons. The descriptions and figures by Carter (Ann. Mag. Nat. Hist., ser. 3, vol. II, 1858), show that the male cells of Eudorina before, during, and after division compare closely with the aspect of ordinary spermatocysts among Metazoa. The bodies are gathered at the periphery in one hemisphere of the cyst and the tails occupy the other or protoplasmic end, thus at once raising the question, whether the bodies are not from nuclei, and the tails protoplasmic in origin as in Metazoa? In a subsequent article (ser. 3, vol. III), the same author also describes the male and female colonies of Eudorina. In giving Bütschli credit as above, it must, therefore, be confined to the homologies of the ovum and the female cell in Eudorina and Volvox, and the spermatocyst and male cells, and also the effects of fertilization and the general comparisons which we note farther on.

The distinctions between Metazoa and Protozoa had not been announced by Haeckel and explained by Huxley (Journ. Linn. Soc. 1876), when Clark wrote on the Infusoria. He was not aware that the sponges belonged to the Metazoa, and very naturally considered them as true Protozoons on account of the collared and flagellated cells which he saw lining the interior of Leucosolenia. How strong this evidence is may be seen by his excellent drawings and observations, and by the fact that Carter, the noted English authority on this branch, and Saville Kent, also well known for his microscopical researches, both maintained the same opinion. The latter even still supports Clark's views, asserting that the ciliated cells become encysted, and that the sponge is not a Metazoon, but really a colonial form of Protozoa.[1] Investigators, however, with this exception, unite in describing the reproductive bodies in the mesoderm of sponges as having true segmentation and being ova. In fact any one who has seen them clearly can hardly come to any other conclusion independently of the fact that they have been followed through their various stages to the sponge form in several species.

We have not seen the impregnation of the egg, nor has any one up to the present time. No bodies similar to polar globules have been noticed, though the stages in which such bodies ought to have been seen were very often under observation. Keller who sought for them in Chalinula notes their absence, and they were also not seen by Schultze in Sycandra, or other authors in other types. We are, however, able to do something towards filling gaps in the history of the development of sponges by observations on the ova and larvae of several species, collected and studied at Eastport, Maine, in 1876. These observations were too incomplete, when made, to merit special publication, but have become of interest as confirmatory, or as supplementary to work published before and since that time by other authors. We did publish in a popular treatise on Commercial Sponges figures of the egg in its early stages, and of the three and six-celled stages and the hollow morula stages of Halichondria and also of a larva of Spongia graminea in Science Guide, No. 3, Boston, 1879, p. 36. In these figures the three-celled stage has cells with nuclei, which we did not see, and the granules around the ova in fig. 23 have nuclei, whereas only the largest of these are ova and should alone have had the nuclei according to our original drawings.

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[1] Bütschli also has lately supported the same view. (Zool. Anzeig., 1884.)

The mesoderm of Porifera may be represented as a germ-bearing layer in any part of which ova may arise from the amoeboid cells as shown first by Schultze in Sycandra raphanus. (Zeitschr. Wissen. Zool. vol. xxv, Suppl. p. 261, pl. 18, fig. 2.) We have seen almost the exact duplicate of this figure in the mesoderm of Tethya hispida collected early in September, but it is interesting to note, that in our drawings of this and other species in which ova were present, none of the cells with long pseudopodia were observable; all the cells, possibly through the action of alcohol, appeared to have become rounded and oviform.

The ova were more numerous in central parts of the body in all forms, but there was no distinct localization of the reproductive cells, since in some like Suberities they occurred even near the base. This of course does not necessarily apply to buds, especially the peculiar forms known as statoblasts. These are distinctly localized, occurring at the base of fresh-water sponges in many species, though not in all and at the base of the Chalinula arbuscula and Isodictya[1] in our salt waters.

Hyaline plasma was present in ova of Hymeniacidon caruncula and increased in size faster than the nucleus. The latter became nucleolated, and subsequently granulated, probably by division of the nucleolus, since a double nucleolus, the two parts still in contact, was observed in another species, at a corresponding stage. In Halichondria incrustans no nucleolus was observed though it was very likely present since the nucleus became filled

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[1] Described since the presentation of this paper at a meeting of the Bost. Soc. Nat. History, Oct. 15, 1884. See Science, Cambridge, 1884, vol. iv, no. 92, p. vi.

with refractile grains. Precisely similar stages with a nucleolus were observed in H. distorta, and also in one example two ova were included in one chorion. A similar nucleus filled with refractile granules appeared also in Chalinula limbata. The nucleus then grows very large in Halichondria, still filled with the refractile grains resembling the original nucleolus, and the plasma in its turn does not increase so rapidly in size. The nucleus expands until it occupies the entire cell, leaving only a shallow zone of plasma, and this granular body almost entirely filled the cyst of one ovum before segmentation occurred. There were more or less granules in the vitellus, at all stages, but these were sparsely distributed in the hyaline plasma and the outline of the nucleus was never obscured, or indistinct; the nucleolus, however, disappeared entirely as soon as the granules appeared in the nucleus.

In all the tissues examined there has been a curious scarcity of the structureless plasma or synctium of authors. We have frequently, especially in Chalinula arbuscula thought we saw a structureless intercellular substance, but it has always upon more minute examination been resolved into cells or closely set granules. In Chalinula living, frozen, or in alcohol, this was found to be the case and though the methods of preparation were not sufficiently varied to be determinative, the existence of such a large amount of unorganized plasma in the mesoderm as is usually figured seems to me at least in Chalinula to be unlikely. It is interesting to note that Ganin has arived at similar results in Spongilla. "Das mesoderm der Spongilla kann nur als eine einfache Form von Bindegewebe betrachten, in welcher die zelligen Elemente prävaliren und die structurlose, gallertige Grundsubstanz sehr gering entwickelt ist." (Zool. Anz. no. 9, p. 198.) In all the marine species, except Chalinula, my observations showed that the granular plasma, which is not by any means a structureless synctium, was prevalent in the mesoderm and this layer presented quite a different aspect from that of Chalinula. It is possible that this membrane may have different aspects in disease or at different seasons, or under the action of distinct reagents. Judging from the abnormal larvae and the tissues we have seen, we should suspect a considerable range of variation, much more than has been figured.

The ovum is isolated and the cyst in the mesoderm is entirely filled by it often even in specimens prepared in alcohol and glycerine. A membrane with double contour makes its appearance at an early stage, but the cells in this were not seen until the multicellular morula was formed. In Halichondria the cells of this envelope became large and a chorion was formed, tearing with difficulty at this stage notwithstanding its delicate hyaline aspect. The outer surface, however, is roughened by the projecting cells which form a close-set epithelium-like surface at this stage in Halicondria and Chalinula oculata, and arbuscula, Reniera and Suberites. In some specimens of Suberites more than one ovum was sometimes included in the same cyst and might lead to serious errors in studying segmentation since they are liable to be closely compressed, and irregular in number.

We did not see the aggregation of amoeboid cells to form the chorion in Halichondria or Suberites as shown by Keller in his clear delineations of this stage in Chalinula, but as these cells are at first very small and transparent they are easily overlooked.

The eggs which had undergone segmentation had cells filled with granules, similar to nucleoli in aspect, which obscured the nuclei. The earliest stage observed in Hymeniacidon caruncula, Halichondria incrustans, Reniera socialis, and Suberites suberea, consisted of three cells, an azygos, and two bilateral cells which occupied the lower half of the ovum. In a morula of H. incrustans the egg had three segments, as if an orange were split longitudinally into three sections, the azygos cell being angular and reaching to the centre, but smaller than either of the other two, which came up on either side to the periphery. The base of the azygos cells occupied only about a fifth of the whole circumference of the ovum and each of the other cells two-fifths. It is, however, evident from our drawings that great variations in the form and size of the segmentation cells exist in the same species.

The azygos cell in Suberites suberea was in most cases fusiform in section, and extended somewhat beyond the centre of the egg, while the two lateral cells reached up on either side forming the halves of a thick divided crescent, the base of each cell occupying about a third of the circumference. In another specimen of Suberea at the same stage a similar outline was observed, but the two coronal cells, as we propose to call the ectoblasts at this and in succeeding stages of segmentation, formed a sort of crescent, the azygos being rounder and less pointed. In other specimens of the same species on the other hand the ovum was more elongated, and the azygos cell was in outline like the carapax of a beetle, the coronal cells being like the wing covers. The azygos cell occupied nearly one half of the length of this ovum, and its longest transverse diameter was about one-fourth longer than the longitudinal diameters of either of the other cells. The base of the azygos cell occupied about three-sevenths of the whole circumference, the bases of each of the others two-sevenths. It was found by means of intermediate forms, and by differences observed on the two sides of specimens, that the first form could not be separated from the others and one specimen showed an outline like Keller's Chalinula in the bicellular stage, except of course that the lower cell had a vertical line of division and the upper cell was smaller than the two lower. This indicated that certain doubtful bicellular forms which we also observed in this species were true bicellular stages. The ovum, therefore, has first transverse division as in Keller's Chalinula, and probably other forms of Carneospongiae and then multiplies the lower cells by vertical fission.

In the next stages the coronal cells multiply by division, while the azygos remains for a time single. Four coronals were present in some specimens making with the azygos five cells, and in others five and six coronals were observed, making six- and seven-celled stages in all the species named above.

In H. incrustans, similar stages were observed except that the fifth and sixth coronals were very small in some specimens, and in Hym. sulphurea? a sixth minute coronal arose close to the azygos. The size of these coronals indicates, that they were due to the unequal division of the larger coronals.

No segmentation cavity appeared at this stage in Hal. incrustans, Hym. caruncula, R. socialis, or S. suberea but in sections of the ova of Hym. sulphurea? a large segmentation cavity was distinctly seen, the ovum at this stage being in this species several times larger than in Halichondria or the other species of Hymeniacidom or Suberites.

There is also among our drawings the ovum of a species of Hymeniacidon with one enormous azygos cell and two comparatively very small coronals, the azygos being more than twice the size of both coronals combined, in the two specimens figured. This agrees with Keller's observation upon the large size of the primitive azygos cell in the bicellular stage of C. fertilis.

The presence of an azygos cell at such an early stage, indicates, that the unequal segmentation observed by Keller in Chalinula fertilis is, as surmised by that author, of general importance. Barrois first noted the same facts among Keratose sponges. (Embryol. de quel. Eponges de la Manche. Ann. Sci. Nat. s. 6.) Tom. III. His larva in Aplysina Verongia showed unequal division, and is figured at an older stage than Keller's Chalinula, being already multicellular. Barrois, however, from differences in color was led to conclude that the pigment-bearing cells of one pole were the same as the dark-colored granular cells of the basal area in still older stages, and Keller strengthened this statement by following the history of the largest of the two primitive segmentation cells of his larva. The primitive segmentation in C. fertilis produces two cells, the upper the largest. These split into four, the lower equally, the upper unequally. The largest portion of the upper cell becomes central and remains for a time undivided, the three cells below, equivalent to our coronals, then divide more quickly and become the "ectoderm" cells.

Barrois' figure of Halisarca lobularis (Ann. Sci. Nat. ser. 6, vol. III, pl. 15, f. 24–25) agrees closely with these stages in Keller's figures, and show, that, though no difference in color at the two poles occur as in Keratosa, there is a difference in the cells. Barrois notes that the three-celled stage is so prevalent in his embryos that it is probably the next stage after the bicellular thus agreeing with our observations in Suberites and Halichondria. He supposed that this differentiation did not take place in Halisarca and the Halichondrida until a comparatively later larval stage, but in this he was probably deceived by the absence of distinct coloration.

Carter's figure of the ovum of Harlisarca lobularis (Ann. Mag. Nat. History, 1874, pl. 20, f. 4) has two cells with definite nuclei seen under compression, f. 5 has four cells and apparently this is a truly four-celled stage, f. 6 on the other hand shows six coronals and one azygos. The remaining stages exhibit the multicellular morula.

In Metschinkoff's figures of the stages of segmentation of Halisarca Dujardinii (Zeitschr. Wissen, Zool. vol. 32, pl. 20, f. 5–7) bicellular, four-celled, and seven-celled stages are delineated. All of these have in each cell a nucleus and in the seven-celled stage nucleoli appear. The four-celled stages f. 6, and the seven-celled f. 7 are both similar to the lower side of ova respectively in the five- and seven-celled stages which we have seen as described above. His f. 8, a section with twelve coronal cells and f. 9 a view from the outer side of the same egg with ten coronal cells show, that the egg had twelve coronals, and f. 9 exhibits five small cells above, which are probably due to the division of the azygos cell or at any rate evidently represent the endoblastic layer.

Schultze (Zeitsch. Wissen. Zool. vol. XXVIII, 1877, p. 31) denies that he has seen in Halisarca lobularis the eight-celled stage of Barrois with six coronal cells around the centre and the two others at the top and bottom of the morula. This would be a direct reversion to the Calcispongian embryo and is probably rare since other authors have not remarked it. Schultze also observed the three-celled stage and attributes it to the division of the larger cell of the bicellular stage, and a still further probable division of the two coronals into four corresponding to our five-celled stages and then adds, " Aehnliche Unterschiede lassen sich auch bei den weiteren Furchungsstadien nachweisen."

Sollas (Quart. Journ. Micr. Sci., 1884, no. 96, pl. 37, f. 1–7,) gives in section stages of H. lobularis, which may also be compared with the above, and his abnormal stage (f. 3) with three cells is evidently a true normal stage somewhat distorted. The bicellular stage (f. 2) is figured as having one very large and one small segment. This stage is described as occurring sometimes, and the five-celled stage as having the fifth cell central and in the same plane with the four coronals, and sometimes in the same circle with them. The whole of these preparations have the aspect of being abnormal, and similar to some abnormal ova which we describe farther on. His structureless blastema which plays an important part in succeeding stages appears also to be artificial, or else an abnormal, product; since it replaces in these preparations the normal membranes of the blastula and succeeding stages, which we have repeatedly seen to be exclusively cellular, as generally described by other authors.

These observations, and our own, render it probable that the azygos cell and the differentiation of the endoblast and ectoblast are probably common to the earliest stages of segmentation in most of the groups of the Carneospongiae, though not yet observed among Keratosa.

The stage shown in Keller's figure 12 (op. cit., pl. 18) where the ovum has a large "endoderm" cell above, and six "ectoderm" cells below is equivalent to the seven-celled stage in Suberites and Halichondria; the central "endoderm" cell is the azygos cell, and the six "ectoderm" cells are in position and appearence the precise equivalents of the six coronal cells. A difference in color enabled Keller to see that this azygos cell by its division gave rise to the cells of his "endoderm" or endoblast layer which filled the interior and plugged up the opening or what would otherwise have been an opening in the ectoblast layer. The corresponding stage in Halichondria incrustans, Eastport, was characterized by the farther division of the coronal cells and of the azygos cell, which were not traced. The morula became multicellular and a hollow amphiblastula of one layer was formed, the cells being exceedingly irregular in some specimens, and quite regular in others.

In Hal. distorta and panicea? and Hym. caruncula, similar morulae were observed which appeared to be solid for periods more or less prolonged and then became hollow. In Chal. limbata a solid morula was present and seemed to remain solid until a late multicellular stage. No distinction between the cells in respect to color, or form, was observed in the outer layer, and yet the centre in Chal. limbata was loosely filled with smaller cells which we supposed to originate from delamination as in other species. These examples show that the differentiations apparent in the earlier stages of the morula, were not necessarily visible in succeeding stages, but that they were usually succeeded in the species mentioned by a form indistinguishable from an ordinary archiblastula. In species with colored cells, however, the amphi blastula is apparent and it is probable that all others are also really amphiblastulae. The conclusion is also sustained by the appearance of a few larger cells around the blastulapore in some specimens. It is evident, however, that such a form contains in part at least the inclosed elements of a mesoderm and is really a primitive Parenchymula, and not a primitive Planula.

The walls were either double or single on different sides of the same amphiblastula in Halichondria; when double composed in one place of large cells and in another perhaps of small cells of irregular shape, or even mere granules. The inner cells alone are replaced by granules which are evidently derived from the bursting or disintegration of these cells. Whenever two or more of the internal cells occurred at the edge of the blastulapore the aspect was such as to entirely mislead the observer into the belief that he was looking at a true gastrula. This was the case in a blastula of Tethya hispida where my drawing shows, however, that only one side of the blastulapore really had a double row of cells, the other side being composed of a single row. Another drawing of this same species had in optical section from the side precisely the appearance of a true double-walled gastrula, and yet I have no doubt that it was simply a case in which delamination had occurred more extensively than is usual at this stage. The blastula was not a closed sphere in these specimens, and each undoubtedly had a distinct large opening at the smaller end surrounded in Hal. panicea by four large cells. A similar blastula and opening was seen in a species of Reniera, but having a single layer of nucleated cells of regular shape and size. In another specimen of the same species, however, about one hundred morulae were examined, many by sections. All were composed of large cells, the interstices filled with granules and small cells. Among these no two were exactly similar on account of great variations in size of the cells, though the ova were all of about the same size, and found in the same sponge. All of these were solid to the centre, except one, which was hollow and had only a single layer of cells of variable size but no granular protoplasm. This stage may have been a true blastula. It had an exceedingly small aperture but this was not like a true blastulapore, and may have been produced by accidental rupture. These ova were at least twice the size of those in other specimens of the same species collected at the same date, and the great irregularity of the cells makes it probable that they were either diseased, or unimpregnated. They are similar to the probably abnormal specimens described by Dr. Sollas and referred to above. We have also seen more advanced stages presenting similar pathological irregularities in Chal. limbata and Hal. distorta.

An amphiblastula of Tethya hispida was observed in which the dome-shaped mass of endoblast cells formed one pole and the remaining four-fifths to five-sixths of the oval body was occupied by the still unciliated cells of the ectoblast. This specimen was carefully studied and figured while living, and no blastulapore was present. The cells of the endoblastic cap were slightly larger than those of the ectoblast, but all distinctly hexagonal. The cap at first sight reminds one of the outer layer of the endoblast cells as figured by Keller in Chalinula fertilis (Zeitschr. Wis. Zool. vol. xxxiii, pl. 18, f. 14) and were marked off by an exceedingly distinct but shallow and narrow constriction. That it was hollow, seems to be assured by the examination of two other embryos of the same species collected in the same dredging. These had been treated with picric acid and were precisely similar in every way but slightly smaller, and each showed a blastulapore in the centre of the endoblastic cells. In one, the cells of the rim were seven in number and larger than the surrounding cells, while in the other no difference was apparent. This opening is similar to that of Halichondria described above, and to that figured by Oscar Schmidt in Sycandra raphanus in a later stage after the larva was more fully matured, the endoblast being ciliated. (Zeitschr. Wissen. Zool. vol. 25, supp. 1875, pl. 9, f. 4–5.) The opening does not seem to have been due to reagents, or to have been closed by contraction in the living specimen, we think it the exceptional retention of a younger characteristic in the later stages of the embryos in which it occurs. Contraction would be more likely to close an orifice than to make one.

We have also observed several embryos very similar to the amphimorulae of Tethya, but presenting older characteristics, being solid and in one example with an endodermal ciliated hemisphere. This is very finely indicated in Keller's remarkable figure of the larva of Esperia Lorenzii, pl. 20, f. 26, p. 341. In this larva with a cap of uncolored cells and ectoderm ciliated, the interior is solid and continuous in the cap, and in the centre is a group of colored cells as if the endoderm were represented.

We have also a figure of Halichondria distorta with precisely similar form, though younger. The ectoblast cells are not ciliated, and there was also a continuous perfectly transparent mass filling the interior, and rising up posteriorly as in Keller's larva of Esperia. We did not define the cells of the interior, but simply noted its homogeneous transparency. The figure of the later stages of this species showed the usual larva of Halicondria with the central mass of spicules. In Chalina oculata, we also found a very similar though older larva. This was at first supposed to be an intrusive Calcispongian, but its size and the peculiar smooth and hyaline, structureless aspect of the posterior region indentified it as a true chalinoid larva of the same age as Keller's Esperia. It was exactly oval and had the cells of the anterior larger part ciliated. The resemblance to the amphiblastula of Calcispongiae showed that closer comparisons could be made between them and Carneospongia than had yet been attempted.

A gastrula was observed and figured in Halisarca Dujardinii having two layers, the outer with the usual cylindrical cells and the inner of smaller more or less compressed epithelial cells. Haeckel is quoted as having figured a gastrula of Halisarca in his papers on the Gastrula theory, but we have failed to find the figure in the Jenaishche Zeitschrift. Our gastrula had the aperture rather large, but in other respects exactly resembled the double-layered planulae and gastrulae figured by Haeckel in his Calcispongiae. Schultze (Zeitschr. Wissen. Zool. vol. xxviii, f. 20, pl. 4) figures what may be the beginning of a permanent gastrula in Halisarca lobularis having cylindrical cells, and below in the same figure, which includes several larvae, there is a planula, becoming filled with mesoblast cells. These figures are exceedingly interesting because the embryo has no endoblastic cap or collar as figured by Schultze, and also, is advanced to a comparatively late stage in which the endoblast cells become converted into ciliated cylindrical cells before becoming invaginated. Dr. Sollas (Quart. Journ. Micr. Sci., vol. xxiv, p. 609) has described gastrulae in Hal. lobularis as habitually occurring, and asserts, that "the course of development invariably leads to one constant result, *i. e.*, the formation of a folded sac, the walls of which are invariably composed of two layers of similar cells, with nothing except an almost imperceptible residuum of structureless blastema interposed between them." This layer of "structureless blastema" is evidently the layer which has been described as the cellular and partly granular mesoderm, its aspect being possibly due to the modes of preparation, or some abnormal conditions in the specimens examined by Dr. Sollas. If Dr. Sollas is not in error we shall have to admit that the single wall of the blastula may originate in two ways in the same group, and even in the same species, in one case from free cells, as claimed by him, and in the other from segmentation, as claimed by all other observers. His descriptions and drawings certainly seem to show that a gastrula forms the three-layered embryo in the stage having cylindrical cells in the endoblast as well as the ectoblast, but there are serious objections to the folded gastrula (pl. 37) as a normal young stage of Halisarca lobularis. It seems contrary to all other observations, that ampullae should arise in this way as folds in the walls of a gastrula, or that there should not be some representation of the Cinctoplanula and Ascula in this species. It would, if true, be an extraordinary case of abbreviated development and of great importance to the morphogenesis of Porifera. That the endoblastic hemisphere may become collared and ciliated is shown not only by these stages, which cannot be otherwise explained, but also by the direct observations of Saville Kent (Ann. Nat. Hist., vol. II, ser. 5, p. 142, pl. 6.). He describes the so-called swarm gemmule in Grantia compressa as passing from an amphiblastula (f. 11) with one hemisphere ciliated and collared, to a stage in which (f. 12) all the external cells are furnished with these organs. This author testifies to having seen the last stage in other sponges, and considers it a natural sequence to the first. That the collared stage occurs in Halisarca lobularis, however, is distinctly shown by Barrois (Ann. Sci. Nat. Sec. 6, vol. 3, pl. 15, f. 31–32.)

A stage similar in all respects to the one figured by Schultze in Halisarca and referred to above was observed in Hym. caruncula, and Chal. limbata. A section of the former showed the interior to be filled with small cells of uniform size and the external membrane made up of the usual layer of cylindrical and flagellated cells. The larva was round or ball-like at this stage as in the preceding morula. Chal. limbata at the same age had a similar form with collared and flagellated outer layer and the centre was filled with cells which were more irregular in size, and surrounded in part by granules. Among these small cells occurred a group of clear cells of larger size with very large nuclei lying in an irregular group close to the inner side of the external layer. They were similar to the cells in Metschnikoff's figure 17a (ibid. pl. 23), and the form and structure of this ovum was similar to the larva (f. 16) from which these cells were taken, and like this also it was still in its chorion. This embryo, also with the exception of the cylindrical form of the cells and the abundant protoplasm in the interior was a counterpart of the blastula of the Echinoderms figured by Selenka (Zeitschr. Wissen. Zool., vol. xxxiii, pl. 5, f. 2), and the mesoderm cells are similar, but more irregularly arranged. This stage is evidently developed out of a Parenchymula, and the internal layer must be looked upon as derived from delamination, at least in part from the endoblastic cells. Schultze figures several larvae in this stage, especially a section of the larva of Aplysina sulfurea (Zeitschr. Wissen. Zool., pl. 24, f. 30), but his connective web of granular protoplasm was not visible in our larvae. The larva of Hym. caruncula was older and the internal cells were similar to those of the denser homogeneous contents figured by Metschnikoff in the larva of Halisarca Dujardinii (ibid. pl. 20, f. 12.). In an evidently older and larger larva of Chal. limbata the form had become elongated or oval, though no indications of the collar had yet appeared. The internal contents had assumed the homogeneous cellular aspect of the larva as just described, in Hymeniacidon and Halisarca.

These facts, and those given farther on with regard to the permanent gastrula in Calcispongiae, make it probable that the invagination occurs after the formation of the ciliated endoblast and possibly at earlier stages in some species. That it may be considered as instrumental in forming the eudoderm and is correlative with the collar in the Cintoplenula is also evident. That the gastrula precedes the collar in development is shown by the facts cited above and also the following. In two of our specimens of the ova of Spongia graminea the area of the blastopore is concave, in a third a deep cut is present, and in still other larvae of the same size and in the same sponge this area is flat. We have also drawings of the ciliated larva of Halichondria Dickiei from Eastport, in which this area has the form of a shallow cup, deeper and without the collar-like projection figured by Keller in his gastrulated larva. The larva figured by Keller in C. fertilis (op. cit., p. 338) as a probable gastrula was somewhat older, and the cup is in the blastoporic area itself after this part and the collar were fully formed in the cinctoplanula.

We have considered the question whether these last might not be accounted for by contraction. In Halichondria, however, the cup occupied the whole of the blastoporic area, which had no signs of a collar, and it was also of considerable depth, while in somewhat larger specimens from the same sponge the blastoporic area was completely plugged up, and as is usual in Halichondria the bases of spicules were visible. At still later stages in larger larvae we also observed the protrusion which forms the collar. In a larva of Spongia graminea from Florida the cup reached inwards nearly half the depth of the body. While Keller's gastrula with its shallow cup might possibly have been due to contraction, those we have described cannot be accounted for in this way. Another fact in favor of this conclusion is the absence of any similar cups, after the projecting endoblastic collar is fully built out, in any of the Chalinulae, or Keratosa or Silicea observed by the author. The collar may vary greatly in form and even protrude like the neck of a vase, as it did in one vase-shaped larva of Spongia graminea, but no gastrulated cavity or cup formed into which the collar or any part of it disappeared. The gastrula evidently occupies a stage between that of the amphiblastula, or the parenchymula when that is present and the cinctoplanula or girdled planula. After the gastrula stage has been completed and the larva returned to its oval form, or during this process, the collar cells appear on the rim of the blastopore, and begin to form this organ.

Marshall (Zeitschr. Wissen. Zool. vol. xxxvii, p. 235) supposes that the collar is produced by the breaking through of internal cells, which press the pigmented cells outward into a circular band. As stated by Barrois the collar appears to homologize with the crown of large cells in Sycandra raphanus which surrounds the true blastopore, and according to Schultze is useful in assisting the larva to fasten itself to surfaces. These coronal cells are, however, really formed from modified ectoblast cells, and, as Barrois pointed out, must be considered as a third differentiation occuring in the embryo between the ectoblast proper and the endoblast, though not as supposed by that author necessarily mesodermic cells. The position occupied by the collar, its sharp outline, color, and functions indicate, that it is a third part in the larva, and Keller's observations support Barrois' opinion that silicious spicules arise in the collar or from cells belonging primitively to this part, and that the collar is a primitive mesodermal layer. The color in Keller's figure appears to make this probable, but on the other hand there are no convincing specific observations either by Barrois or Keller, which would do away with the impression made by the constant presence of spicules only in the central uncolored cells of the blastoporic area and after the larva becomes plugged from the interior. They are parts of the central layer proper coming to the surface in the central core of the blastoporic area, and the collar appears to us in the larvae we have studied to be an entirely independent derivative formed out of the older ectoblastic cells. The internal outlines in Spongia graminea and Chalinula limbata when the collar is fully developed are sharply defined, and do not permit us to imagine any connection between the collar cells and spicules.

If it had been possible to illustrate this paper we could have given figures of several larvae of Halichondria with the spicules unquestionably gathered into a sheaf in this core, with their ends coming to the surface, and also similar cases in Chal. limbata. In this last, threads, evidently horny and more or less sinuous, occupied the place of straight spicules. This, to us, is a strong argument for the derivation of the cells in the plug through an invagination of the outer layer of the larva. We have held (Mem. Bost. Soc. Nat. Hist., vol. II, p. 482) that keratode was found in invaginations of the ectoderm, and have now drawings of the internal structure of Chal. arbuscula which leave no doubt that these invaginations occur as figured by Barrois, and that the threads are surrounded by a perifibral membrane, the cells being similar to those of the ectoderm and continuous with them. This perifibrum envelopes the spicules as well as the fibre and leaves no doubt that they are all inclosed, but whether the epidermal cells give rise to the spicules we could not ascertain, though this was an almost necessary inference from our observations and those of Barrois'. The cells of the perifibrum as observed in Halichondria and Chalinula were very long, fusiform and flat, and though occasionally loaded with granules were never gibbous or similar to the spongoblasts of Schultze, which should, we think, be styled keratoblasts. A similar membrane has been discovered by Von Lendenfeld in Aplysina, and described in his papers on Australian Sponges. Oscar Schmidt has given the best figures of the spicules in their early stages in a larva of Esperia (Zeitschr. Wissen. Zool., vol. xxv., supplem. pl. 10.) Such observations have been generally considered as confirmatory of the views that the collar is mesodermic, but in our opinion it shows simply that invaginations of the outer layer of the body may have similar functions, whether occurring in the embryo or in the adult. Such invaginations may be expected to build either spicules, or keratode, or both, in varying proportions according to the hereditary form and needs of the sponge. Thus the gastrula not only serves to place the endoderm in position, but also builds the plug in the narrow neck of which is formed the fan-like fascicle of spicules or threads commonly found in the cinctoplanula, and afterwards apparently dispersed in the mesoderm, though always we think surrounded by the perifibrum.

The variability of shape in the collar and its large size in Carneospongiae, and the stiff setae, suggest that it may be an organ destined to assist the ovum in freeing itself from the tough membranous envelope. Though no author has observed a chorion in the Calcispongiae, it is very probable that the "Deckzelle" of Polaejeff is the chorion, or its homologue. Whether it is tough or not we do not know, though it is plain that the ovum breaks out of the chorion, as a rule, at an earlier stage than among Carneospongiae. The occurence of calcareous shells in the ova of Sycaltis testipara, Haeckel, Calcispongiae, vol. II, p. 271, pl. 47, and Sycaltis ovipara (ibid. p. 275, pl. 47) is interesting in this connection, but whether contradictory or confirmatory of our suggestion cannot now be determined.

An elliptical opening also appeared in the chorion of Hal. incrustans, through which the cells of the embryo escaped when under sufficient pressure A similar opening, supposed to be a micropyle, was also seen in Suberites in the multicellular morula, but with the rim much thicker than the walls of the chorion layer. It becomes interesting to note also, that this layer absorbed aniline, like the soft keratode of the young fibres of Chalinula, when staining was tried in a species of Isodictya, and when viewed from the side in Halichondria the impression was that the cells contained highly colored keratode in a granular form, and that the walls of these cells were more or less stiffened or affected by internal deposits of some sort. The walls, however, did not seem to absorb color in the same degree and behaved more like the older keratode of the fibre in Chalinula. This result cannot be considered satisfactory, but the membrane is tough and essentially protective.

The use of the blastoporic area as a larval base of attachment enables us to account for the variety of ways in which the embryo carries itself, and becomes attached. In some forms any part of the body may serve as the base, and in Reniera filigrana, as stated by Marshall, the embryo may even reverse the usual position and in moving, carry the blastoporic area in front and become attached habitually by the posterior or primitive cloacal end. This is easily understood if we grant that the function of attachment is a secondary or acquired habit, not a primitive use. It would be liable to great variation and some larvae might entirely revert to the primitive position in moving and in becoming attached as in R. filigrana.

As regards the opposite pole it may be readily observed that the ectoderm is in all the earlier stages continuous. Marshall (Zeitschr. Wissen. Zool. 1882, vol. xxxvii, pl. 13), has figured the aboral pole of the larva as being open, and plugged with the internal cells which have broken through as at the other pole. This aperture in the ectoblast, which is the primitive cloacal opening, we have seen plainly in Spongia graminea, with the internal cells protruding and continuous with the internal con tents. This fact we also observed and noted in Sp. graminea (Mem. Bost. Soc. Nat. Hist., vol. II, 1878, p. 506); and subsequently realizing that an actual opening was formed, published a figure in Science Guide, no. 3, p. 26, ed. I, 1879. The projecting cone which marks the site of the opening of the future cloaca has been seen in the larva of Suberites, Tethya, Chalinula and Spongia, by Marshall in Reniera, in Verongia by Barrois (op. cit. f. 41), who calls it "la papille anterieure." Carter observed it in Halisarca, and he saw in Halichondria the transformation of the "papilla" into the primitive cloacal crater. (Ann. Mag. Nat. Hist., vol. XIV, pl. 22, p. 335.)

This appears to sustain Marshall in his conclusion that the primitive cloacal canals, as in Ascones, must be considered as normally lined by the endoderm at least in the early stages of Carneospongiae. The best discussion of this view, as contrasted with Schultze's opinion that the incurrent canals are formed by an invagination of the ectoderm and that the endoderm is confined to the ampullae and cloacal branches, has been written by Von Lendenfeld in his Monogr. Austral. Sponges (Proc. Linn. Soc. N. S. Wales, vol. IX, pt. 2, p. 313, 318.). The embryology as well as the physiology of the Sponges according to this author appear to favor Marshall's views. Our own view is quite distinct from this, as will be seen farther on.

Immediately after the larva becomes attached, as shown by Schultze in "Die Plakiniden" (Zeitschr. Wiss. Zool. vol. XXXIV, 1880), two hollows are formed in the solid core lined by the endo dermal cells which arise from the core (primitive mesoderm, Marshall's coenoblast, and form an epithelial lining around the two separate cavities, which coalesce subsequently into one. Marshall in his article on "Ontogeny of Reniera filigrana" (Zeitsch. Wiss. Zool., vol. XXXVI, 1882), figures the larva as filled up solidly by a "coenoblastic" membrane in which a central cavity appears surrounded by the cells of an endoderm and a mesoderm both differentiated from the "coenoblast." This name appears to us to embody an essential distinction which ought to be made between the primitive layer and the endoderm and mesoderm which arise from it, if Marshall's view is true. The colored cells in the interior of Esperia Lorenzii and the arising of the endoderm from invalarva gination in Calcispongiae and probably also in Carneospongiae appear, however, to decide that this term cannot be admitted. The lining cells of the gastro-vascular cavity are not at first ciliated and the ampullae, according to Marshall, arise in connection with them by invagination of the lining cells of the main cavity. The cells which line the lateral cavities or ampullae do not, however, retain the characteristics of the epithelium from which they originated. They acquire collars or funnels on their free ends and also flagella.

We think it will be found convenient to apply the term Ascula to the first period of attachment, that in which the sponge has lost or is just losing the collar, opening the primitive cloacal crater, and forming the first central cavity without lateral ampullae. We have not been able to separate the Protospongian stage of Haeckel from the ascula and think it should be merged in the latter. The cinctoplanula cannot be considered to be identical with this or the ascula, or to imply an ancestral form such as the protascus of Haeckel. It indicates the previous existence of a stock of forms more differentiated than the parenchymula and quite distinct from the hydroplanula, but certainly not a protascus. We can conveniently use Haeckel's name of Archispongia for these supposed ancestors, and, therefore, employ it in this sense.

According to our experience among fossils, especially Cephalopoda, there is no stable characteristic of the young, however minute, without its forerunner in the adult of some ancestor; and we think, therefore, that the collar, though apparently an egg-organ, indicates an adult ancestral type possessing a similar structure. We realize that there may be important organs which appear in the larva, and have never been possessed by adults, but many are hastily assumed to be of this kind before being proved to be so. Even the egg-tooth of birds and reptiles, though possibly one of this class, depends upon negative evidence, and may at any time be shown to have a genetic significance. While believing in mechanical evolution and purely physical forces, it seems not at all philosophical to accept even apparently obvious reasons without close examination. Adaptation has been assumed with reckless prodigality as sufficiently accounting for the origin of characteristics and forms in the larvae, especially of insects, when experience teaches that similar modifications, among the Batrachians for example, though adaptive, have their origin in structures found now to belong to ancestral types. Balfour's remarks on the meaning of the larval stages of insects (Comp. Embyol., vol. I, p. 352) are very valuable in this connection. He attributes more fully than we should be disposed to do, the "origin" of larval characteristics as due to adaptation, and also states that "on grounds already indicated it may be considered certain, that the groups of insects without a pupa stage and with a larva very similarly organized to the adult preceded the existing holometabolic groups." The presence of the collar in sponges is interesting in connection with Lankester's theory (Journ. Micr. Sci., vol. XVII) of a primitive architroch, based on the homology of the praeoral circlet of cilia, which occurs in the larvae of Molluscs, Annelids, Rotifers, and Echinoderms. "All these forms can, it appears to me, be derived from a ciliated girdle which was developed in all probability around the ancestral organism by a specialization of the ciliated ectoderm at a time when the organism was teleostomate." There is an apparent correspondence of this ciliated band in Porifera and Echinodermata, and we can follow its development in detail among Porifera, as a differentiation of the rim of the blastopore, thus completing Lankester's picture of the Architroch, and his explanation of the oral origin of the band. It was probably primitively a mouth organ of the ancestral gastrulated Architroch, similar to the circlet of cilia in the Protozoa Ciliata, and having possibly similar functions. That it must have been an important organ of the probably common ancestral form of the invertebrata is, according to our standard, shown by the characteristics of the cinctoplanula, and its probably subsequent adaptation to the purposes of attachment in the ascula is simply a curious example of secondary adaptation.

In Carneospongiae the larva has the cloacal knob and the pear-form, which are parts of the ascula stage, appearing often long before fixation, and the formation of the ampullae is much quickened and concentrated. These may be formed even in the free larva in some species. The resemblances to the vase-like ancestors of Ascones are thus almost obliterated, being represented only in the pear-form and confined to the free larva in its last period, and to the ascula stage in some forms.

The primitive cavity occurs as shown by Marshal and Schultze, in the young of some forms with the epithelium unciliated as in the cavities of Sycones and Leucones. Such concentration implies the descent of the existing Carneospongiae through a series of forms having a complex gastro-vascular system and intervening between the radical Archispongiae, and the existing Carneospongiae. These, as suggested by Haeckel, may be represented today by the Myxospongiae, whose ampullae are diverticula, opening directly into the cloacal canals, and have a close resemblance to the ampullae of the adult Sycones and some Leucones, as well as the young of Carneospongiae. This stage, in which the lateral ampullae are first formed in the young of Carneospongiae, we propose to call the Ampullinula, because the name protospongia, as defined by Haeckel, and applied to a single vase-like form without spicules immediately preceding the olynthus (Calcispongiae, vol. I, p. 347) is not applicable to such an advanced and complicated organism.

A summary, or provisional classification of the stages of growth in their natural succession as they might all appear in any one animal, may be given as follows: After the first stages of segmentation have formed the amphimorula, there appears (2) an amphiblastula in which this differentiation becomes less apparent through the multiplication of cells in the endoblast. During these two stages a segmentation cavity appears, and either remains empty or may be partly filled by the rudiments of a mesoblast arising by delamination from the wall. Whether these rudiments include only the granular part of the future mesoderm remains to be decided. The amphiblastula has a blastulapore, which becomes subsequently closed; then (3) an amphiblastula, in which the differentiation between endoblastic and ectoblastic hemispheres becomes again apparent, but the cells retain their rounded segmentation outlines; then (4) an amphiblastula in which the cells of the ectoblast acquire flagella and become more crowded, losing somewhat of their primitive aspect. The endoblast, however, still remains with smooth, comparatively unaltered cells; then (5) a stage in which the cells of the ectoblast acquire collars around the flagella and become cylindrical. During this and possibly during the preceding stage a temporary gasrula may be formed. When the invagination of the endoblast is complete in this stage, the embryo may assume the aspect of the next stage if viewed externally. Then (6) a parenchymula in which the cells of the endoblastic hemisphere also become cylindrical, and acquire collars and flagella; then (7) a stage of the parenchymula in which a gastrula may be formed by invagination of the endoblast, and it is probable that the collared and ciliated cells which have been differentiated upon the exterior in the endoblast are carried into the interior to form the endoderm. The blastopore becomes filled with cells, probably part of the invaginated cells of the endoblast; then (8) a cinctoplanula in which a sheaf of spicules or threads is formed in this blastoporic plug, the embryo resumes its oval form, and the cells of the ectoblast immediately around the blastopore become highly colored and are transformed into a collar; then (9) a stage of the cinctoplanula in which the collar is completed, the spicules become more generally dispersed throughout the mesenchyme, the long setae of the collar are formed, and the embryo breaking through the chorion becomes a free larva; then (10) the ascula, when the larva becomes attached, the ectoblast cells lose their cilia and form the the ectoderm. The primitive cloaca and a central cavity, surrounded by an endoderm, appears in the interior; then (11) the ampullinula, in which the central cavity branches and lateral ampullae with collared and flagellated cells are formed by invagination together with their incurrent pores.

The embryo of the Calcispongiae, as described by Barrois and Schultze among Sycones, has at first two cells, then four, then eight. At this stage the mode of segmentation changes; the cells which have been previously formed exclusively by vertical fission, and are assembled in what we have called a monoplacula, begin to multiply by transverse fission; the upper points of the eight original cells are cut off from the rest and form the apical cells of Schultze, while the lower cells become the basals of the same author. In this way the primitive differentiation of the placula into two layers is established in what we have designated the diploplacula, on account of the flattened form of the embryo. The apical cells are the equivalents of the azygos cell of the Carneospongiae. The eight apicals spread out at first and form with the basals, which are the equivalents of our coronals, an amphimorula having apertures above and below. The aula (as we have for convenience sake designated the cavity of a colony of Eudorina or Volvox) is represented at this stage only by the tube connecting these two apertures, but in the next stages the growth of cells by transverse division gradually separates these two layers and establishes the hollow sphere of the true amphiblastula, the segmentation cavity or blastocoel of Huxley. The differentiation of the layers does not disappear. It, however, would undoubtedly be difficult to distinguish the two layers in Schultze's amphiblastula (Zeitschr. Wissen. Zool., suppl., vol. xxv, pl. 20, f. 15), if it were not for the differences of color in the basal or ectoblastic cells. The upper or endoblastic hemisphere is very large and is formed not only by transverse division of the primitive basals, but also from transverse division first of the lower parts, and then of the upper portions of the primitive apicals. The upper aperture becomes closed in this stage, but the one through the ectoblast remains open longer, surrounded by the eight cells, or points of the primitive, dark-colored, granular basals. The cells of the endoblast in the next stage acquire cylindrical forms with collars, and flagella, and the basal cells remaining still unciliated divide rapidly, forming the ectoblast, and grow out into a hemispherical outline. The embryonic amphiblastula in its most advanced stage of growth is thus formed and is commonly supposed to be typical for sponges. We have, however, given our reasons for considering older stages, or the cinctoplanula, as more distinctly typical.

The mode of formation of the ectoblast and endoblast, partly by the apical and partly by basal cells, is important, since it enables us to see that Schultze was right in designating the cells of the diploplacula as apicals and basals, instead of employing the usual term of endoblast or ectoblast, or their equivalents. It is evident that these early stages are not the equivalents of later and apparently similar cellular transformations, and that the continuity of the azygos and apical cells with true endoblastic cells, as in Keller's Chalin. fertilis for example, is really due to fusion between an earlier and a normally later and distinct stage. The diploplacula indicates an ancestor with the two layers less differentiated than generally supposed, and certainly in a more primitive condition than is shown by an amphimorula in which the endoblast and ectoblast are separable. This form probably had an upper layer of cells differentiated from the lower, an esoteric as contrasted with an exoteric layer, the representative of these being respectively the apicals and the basals in the earliest stages of Calcispongiae, and in later stages the endoblast and ectoblast cells. These last, however, may be somewhat mixed in derivation, since, as shown above, the endoblast may consist of esoteric or apical cells, with a peripheral rim formed by cells of the exoteric or basal layer.

In the next stage a temporary gastrula is often formed by the invagination of the now fully established ectoblast. The aspect of the embryo at this time in Schultze's figure (pl. 21, f. 24) is precisely similar to my figure of the same stage in Halisarca, except that this has an elongated embryo. The contraction of the temporary blastopore in this embryo or in Halisarca might, as we have suggested above, convert it into a planula with ciliated exterior, and smooth membrane of amoeboid cells in the interior, or a slighter contraction make it into a gastrula with a narrow mouth, and every aspect of permanent invagination.

We entirely agree with Metschnikoff that Sycandra is a specialized form, and that its embryology cannot be accepted as typical or primitive, as has been done by Schultze and Balfour. Nevertheless the ontology has been very thoroughly worked out by Schultze, and we think the development shows that it is a form with concentrated development in which the gastrula appears without the parenchymula, or with this and the cinctoplanula only obscurely indicated, the first possibly by the solid amphiblastula filled with cells derived from delamination of the endoblast, and the latter by the invaginated gastrula and its blastoporic band of larger ectoblast cells, which are the homologues of the collar cells of other embryos.

The thin-walled Ascones are the lowest of Porifera and their embryology is necessarily the standard for phylogenetic comparisons. The Physemaria of Haeckel may be in part, or possibly wholly, true Protozoa, as shown by Saville Kent and Carter (Mag. Nat. Hist., ser. 5, vol. I, 1878.). The former figures an undoubted Haliphysema, one of Haeckel's types of Physemaria, which has an attached, club-shaped body, covered with particles of foreign matter and spicules accumulated upon and incorporated in the external sarcode. It has, also, long pseudopodia extending out of the aperture above and forming the usual sarcodic net-work. All of the Physemaria have to be left for the present in the category of doubtful forms in which we must also place the extraordinary Cameraphysema lately described by John A. Ryder. (Smithson. Misc. Coll. Proc. Nat. Mus., vol. XXII, 1883, p. 270.)

Haeckel describes an apical cell as arising by vertical fission in the eight-celled stage in Asculmis armata (Calcispongiae, pl. 13), in Leuculmis echinus (ibid. pl. 30), and Sycyssa Huxleyi (ibid. pl. 44.). Haeckel also considers the basal and apical cells as all developed in the same plane, and this may have been the case, though the figures of other investigators suggest that when the apical cells were formed there was a change from the monoplacula to the diploplacula. Haeckel's observations also show that the sudden appearance of the eight apicals in Sycandra occurs at a stage when only one apical is usually formed, and this author even describes the apical as not divided into more than four even in the sixteen-celled stage of the three species named above. No three-celled stage has been recorded in any Calcispongian, so far as we know, except in a form with irregular segmentation of Sycyssa Huxleyi, figured by Haeckel (pl. 44, f. 9–13) and described by him as abnormal.

The three-celled stage is, therefore, not prevalent among Calcispongiae as it is among Carneospongiae. The bicellular stage in Calcispongiae is followed, as a rule by a quadricellular, and an eight-celled stage before any change in the mode of segmentation takes place. Haeckel also gives figures of apparently true gastrulae in Asculmis armata (pl. 13) Sencumis echinus (pl. 30), and Sycyssa Huxleyi (pl. 44), but in all of these the ectoblast cells are invaginated and the whole aspect of the larva identifies it as the transient stage of gastrulation. In Ascetta clathrus (pl. 4, f. 6–8, var. mirabilis), a closed hollow planula is figured with only two layers of cells. This stage has not been observed by others, and the aspect of the embryos we have mentioned above leads to the suggestion that Haeckel's planula in these cases is explicable as a transient gastrula, in which as we have suggested the temporary blastopore has been obliterated by contraction.

Barrois' description of the vertical segmentation in the first stage of Gummina minosa in his "Eponges de la Manche," p. 57, leaves hardly a doubt that this sponge is a calcispongian and, possibly one of this class entirely devoid of a skeleton. This impression is supported by his figure (38, pl. 14) which is that of an undoubted calcispongian embryo. His figure of the later larval stage is valuable in another aspect, since, as stated by Barrois, it is a gastrula, or as it has been called since he wrote, a transient gastrula.

Metschnikoff (Zeitschr. Wissen. Zool., vol. XXXII, 1879, pl. 33, f. 1–3) gives the earliest segmentation stages of Ascetta primordialis among the Ascones, and shows that they closely resemble the same stages in other forms. The ova have first two then four and finally seven cells originating through vertical segmentation in a placula. The subsequent stages of the multicellular larva confirm Oscar Schmidt's observations upon Ascetta primordialis, and Ascetta clathrus. Schmidt (Arch. Mikr. Anat., vol. XIV, pl. 15–16) describes the free larva in these species as having a single layer of ciliated cylindrical cells, which change at one pole into a few, large, granulated cells. These, after losing their cilia, become rounded and amoeboid in aspect, and, making their way inwards as wandering cells, give rise to the endoderm. Notwithstanding the distinguished author's opposition to the gastrula, it is possible that this inwandering of differentiated cells may be a primitive stage in the formation of the gastrula. Schmidt and Metschnikoff both describe two kinds of cells in the parenchymula, — the set described above derived from the inwandering cells and another of smaller cells arising by delamination from the internal parts of the endoblast or the ectoblast cells. The habit of building by delamination is a common one in the amphiblastula of sponges, and also the free production of granules by disintegration of cells. When Metschnikoff (op. cit., p. 364.), therefore, supposes the small and clearer cells derived from delamination to be the element of the future endoderm and the large granular wandering cells to be the generators of the future mesoderm, it is evident that one can just as readily consider the smaller cells as destined to build up the mesoderm and the wandering cells as the probable generators of the future endoderm, as they were first considered by their discoverer, Schmidt. This would appear reasonable, if, as we have suggested above, the formation of the granular portions of the mesoderm may begin to appear by delamination at a very early stage in Halichondria. It will be noticed, also, that in the parenchymula and gastrula, as in the adult, the three membranes are similarly characterized. The external and internal are similar and membranous, while the middle layer is remarkably loose in construction and of a more primitive structure, a mere aggregate of cells.

According to Schultze's observation on later stages in Sycandra raphanus, the ciliated and collared cells of the endoblast finally become invaginated, forming a permanent gastrula and a true blastopore; and this gastrula is really an ampulla of primitive form. The larva becomes fastened by the blastoporic end, closes the pore, and opens another, the primitive cloaca, at the free end. Metschnikoff (Zeitschr. Wissen. Zool., vol. xxxii, p. 368) states that he had always held the opinion that the flagellated membrane was invaginated to form a gastrula in Sycandra; and at the time Schultze published was ready to prove his view with sections and preparations. His figures 7–8 (pl. 21) seem to be the ones referred to, and his figure 15 (pl. 23) and description of the three-layered embryo of Ascetta primordialis leave no doubt that gastrulation occurs in the ciliated endoblast among Ascones, as well as in Sycones.

These investigations show that the permanent gastrula occurs by the invagination of the endoblastic membrane in all forms, and that this membrane before invagination takes place is composed of cylindrical, flagellated cells similar to those which appear subsequently in the ampullae. The transient gastrula arising from invagination of the ectoblast in Sycandra is, as Schultze stated, not followed by any structural result, and is distinct from the similar transient gastrula of Carneospongia. These last, being formed by the endoblast, may be legitimately supposed to have some connection with the final appearance and genesis of the permanent gastrula, which is present in all forms. Confusion has been occasioned by this primitive and transient occurrence of gastrulation. If our views are correct, however, the transient gastrula among Carneospongiae may be always distinguished by the fact that it is found at stages when the layers are easily distinguishable from each other as ciliated ectoblastic and endoblastic amoeboidal cells; whereas the permanent gastrula occurs after the endoblast is ciliated and the two membranes in consequence are less distinguishable from each other. Among Calcispongiae on the other hand it occurs when the ectoblastic cells are amoeboidal and the endoblast ciliated; and as the inner layer is in this case formed by the ectoblast there is here also no difficulty in detecting them.

The process of forming this layer by delamination occurs before the permanent invagination of the endoblast in the Calcispongiae as well as in the Carneospongiae and the parenchymula stage is present even in Sycandra raphanus, though it is much abbreviated as above stated. Schultze (Zeitschr. Wissen. Zool., vol. XXXI, p. 269) considers that the middle layer arises from the ectoblast and it became visible only after invagination. It may, however, have existed and probably did exist previously, as in Metschnikoff's larva of Sycandra raphanus (op. cit., vol. XXXII, p. 368, pl. 21) which is described and figured as having an internal layer in the free amphiblastula stage, probably derived from the endoblast.

The later larval stages of development also show concentration but not the extent of abbreviating the proximal ancestral characteristics. The ascula has a simple cavity with a single cloacal aperture, and then follows the adolescent larval stage usually considered as the olynthus predicted by Haeckel; but which, with Vosmaer, we must consider as really an ascon stage. It is undoubtedly a great triumph for Haeckel and the law of biogenesis that it is so closely comparable with his olynthus, but the spicular skeleton, and characteristics are those of the adult Ascones, and it may even be referred to the genus Asculmis. It has four-rayed skeletal or supporting spicules and single acerate defensive spicules arranged as in that genus. We think this close correllation probably means that the distinctions between Ascones, Sycones and Leucones are artificial, and that the genus Asculmis, for example, is a low or radical genus of a sub-ordinal or family group including Sycandra among its higher forms. Such an arrangment, cutting across the lines of classification already laid down and possibly including in the same groups genera of Ascones, Sycones and Leucones, is plainly indicated by the embryology of Sycandra to one practically familiar with phylogenesis. Such a change cannot now be inaugurated, and we, therefore, merely suggest, because the time to follow this idea out can never be ours, that research upon the later larval stages and their corellations, would probably show the thickening of the mesoderm and all its corellative characters to be really homoplastic and not homogenous,[1] arising from adaptation and not genetic except in small group.

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[1] These terms first used by Lankester (Journ. Micr. Sci., vol. XVII, 1877, p. 436) express phenomena with which naturalists have long been familiar better than any heretofore used, and we have accordingly adopted them in place of their synonyms.

This larva of Sycandra is an example of the most frequent and simplest illustrations of concentration in development, and shows how this law differs from the ordinary statement of the law of heredity. For example, Darwin writes: animals tend to inherit the characteristics of their ancestors "at the same or earlier stages." The law of concentration is, however, that characteristics, as a rule, arise during the adult or later stages of growth and tend to be inherited at earlier ages in succeeding generations of individuals, and in descendent groups of all grades. This is the unqualified general statement, but the law has a medium expression in normal forms, and quite another in aberrant or specialized forms. In these extreme examples the crowding of characteristics into the younger stages causes the loss of the useless ancestral characteristics in the embryo and larva. These being no longer repeated, definite evidence of the genetic origin of such forms may be more or less obscured, or even entirely lost.

Von Lendenfeld has observed the law and remarks in his Mon. Austr. Sponges (Proc. Linn. Soc., N. S. Wales, vol. IX, pt. 2, p. 332), as follows: "This later kind of heredity has the inclination to let peculiarities appear earlier and earlier from generation to generation, if these are particularly advantageous to the organism. The sooner the progeny attains possession of pecularities which have shown themselves as useful for ancestors the better for them." "This is the main cause of the series of appearances called, "shortened heredity." The bare statement of the law of concentration differs very slightly as given in Haeckel's Generelle Morphologie, Cope's Origin of Genera, and the author's essay (Memoirs Bost. Soc. Nat. Hist., vol. I) and in Von Lendenfeld's work, but all of these authors, except the writer, are united in the opinion, that abbreviated development is a result of the action of Natural Selection. According to our views of Natural Selection, it is not possible for it to act in this way. If characteristics be divided into two classes, similarities, and differences, Natural Selection is applicable only to the transmission of the class of differences, and is a law applicable to the temporary preservation of the differences between organisms. It is obviously inefficient as a cause for the continued transmission of the vast majority of the characteristics after they have become fixed in the structure, and can be regarded as homogeneous in any genetic series.

Heredity is the transmission of similarities alone and is perpetually and necessarily opposed to the introduction of differences, adopting them only after a struggle more or less prolonged. It is only in this way that we can explain such extraordinary indifference to the transmission of such slight mutilations as the continued piercing of the nose and lips among savages and the ears among civilized races, while in other cases extraordinary sensitiveness is exhibited to the effects of more serious wound, or in certain physiological and structural results which flow from them. Our views and

The ova of sponges, during segmentation, afford some very striking illustrations of the action of the law of concentration in the more specialized forms of the Carneospongiae as contrasted with the less specialized Calcispongiae. The embryos, as we have stated above, become differentiated in the bicellular or tricellular stage in the Carneospongiae, while in Calcispongiae the similar differentiation at the poles of the embryo does not occur until the seven- to eight-celled stages. The embryo of Calcispongiae is also a placula until the same stage, while that of Carneospongiae is an amphimorula in the three-celled stage. The differentiation of the embryo into ectoblastic and endoblastic layers begins, therefore, earlier in the more highly specialized Carneospongiae than in the more generalized and direct descendants of the prototype, the Calcispongiae. If we are correct in our mode of looking upon such phenomena this indicates that the lower sponges sprang from single layered or monoplaculate Protozoa and that this stage became lost in Carneospongiae, and possibly in some specialized or abnormal Calcispongiae, through the action of the law of concentration in development. The following stages exhibit the action of the same law. Thus in Sycandra the cells of the central cavity, according to Schultze, lose the collars and cilia, becoming smooth in aspect like the epithelium of the adult in the lining membrane of the same cavity. Then follows at a later adolescent stage the ampullinula which occurs in Carneospongiae at a much earlier period in the young. In this transformation the sycon appears, the mesoderm thickens, the ampullae are formed as open bags radially arranged around the central cavity and extending outwardly form large sacs opening externally through the pores. The loss of the cilia and collars is thus proved to be a secondary transformation and may be attributed to specializa-

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those of Lankester (Journ. Micr. Sci., vol. XVII, p. 411) on "precocious segmentation" are by implication similar, since he attributes the origin of characters to adaptation and concentration of development to heredity. The idea of precocity is, however, pathological and has, as we have tried to show, a special application to the concentrated development of diseased forms. We have discussed these questions more at length in Genesis of Planorbis at Steinheim (Anniv. Mem., Bost. Soc. Nat. Hist., 1880; also, Proc. Am. Ass. Adv. Sci., vol. XXIX, 1880; and Foss. Ceph. Mus. Comp. Zool. ibid., vol. XXXII, 1883; and Science, nos. 52–53, 1884.) Dr. A. S. Packard (Stand. Nat. Hist. vol. I, p. liii, Bost. Cassino) has stated his opinion, which coincides very nearly with the above, especially in the rejection of natural selection as a fundamental cause of variation.

tion and localization of the feeding function in the lateral ampullae, the cells of which take on anew the collars and flagella, and must be considered as purely endodermic. We are justified by this transformation, occurring in a highly specialized and concentrated genus like Sycandra, in predicting that some of the lower forms will have cells in the diverticula or ampullae which do not lose the collars and flagella, but retain them in unbroken continuity with the cells of the archenteron.

This history of the larval transformations and the study of the general morphology led to Vosmaer's homologies, which are in accord with the above as given in his interesting work, "Ueber Leucandra aspera," and are in agreement also with Polaejeff's similar views and are also in accordance with the researches of Schultze and Marshall upon the ampullinula of Plakina and Reniera. Our view differs, however, from all of these authors as regards the distribution of the ectodermic and endodermic layers in the supply tubes and cloacal canals, as will be seen farther on. Schultze's and Metschnikoff's gastrula settled also the vexed question of individuality, showing that a spongozoon has a ciliated cavity, the walls of which are composed of three layers perforated with pores and having but one cloacal aperture. Thus the ascon or olynthus becomes undeniably the typical spongozoon and we can feel secure in the inference that the ampullinula is a later occurring and secondary form of development, though in Carneospongiae it appears as a primitive stage because the ascon or olynthus form is skipped. Thus we can explain why the endodermal lining of the interior in Carneospongiae is composed wholly of smooth cells, the ciliated cells not appearing until the latter part of this stage in the lateral ampullae, if we attribute the apparently sudden appearance of these cells in the midst of what seems to be the undifferentiated "coenoblast" of Marshall and the appearance of the central cavity, as really due to a former gastrula stage, and consider that it represents the period immediately succeeding the fixation of the gastrula in Sycandra. According to this view the cells of the endoblast become incorporated with the cells of the mesenchyme after invagination, and are not in some cases distinguishable from this middle layer until they begin to form the true endoderm around the central cavity or archenteron, which also reappears at the same time.

Haeckel's definition of the individual or person among sponges, as a single ascon or a branch with a single cloacal aperture is, therefore, only true in the Ascones, and cannnot be true in any fleshy sponge. No Sycones, Leucones, or carneospongian can have a branch springing from a true bud, or spongozoon. Such a branch is not a single ampulla, with its proper walls and cloacal crater but consists of a number of such, and is compound from the start. Thus it becomes plain by means of the embryology and the morphology that these compound branches are merely extensions of the general surface remotely like an arm or a leg, but not spongozoons.[1] A branching carneospongian is not, therefore, a colony, but must be regarded as an individual with a body so plastic and susceptible to the influences of the surroundings as to vary from a sheet, or a solid lump to a more or less irregularly symmetrical branching form in many species according to the locality in which it grows (Microciona and Spongia).

A very graphic account of this problem is given by Von Lendenfeld in his Monogr. Australian Sponges and there he calls attention to the remarkable cases of zoa-impersonalia, or what we should consider as degraded colonies. One example is the Apysilla violacea (Zeitschr. Wissen. Zool., vol. XXXVIII) in which the individuals or zoons coalesce and consequently may spread over many square meters in the waters of Port Philip. Cases of this kind are common in embryos and were first described by Oscar Schmidt; and Potts has recently shown them to be common between the young arising from the statoblasts of Spongilla. All such cases belong to the phenomena of coalescence, and do not at all effect the foregoing conclusions except so far as they show that the sponges are very primitive and peculiar forms. Nor do the independent buds of Tethya or Halisarca, which we take to be more or less similar to statoblasts in their nature, have any bearing upon our statements, which relate only to the peculiar modes of branching prevalent in Porifera.

Vosmaer regards the extension of the cavity into branches as being due to the advantageous nature of the change, and Polaejeff disputes this opinion, declaring that the ascon had the advantage over the leucon or sycon both in the amount of surface covered by the collared cells, and also the ease with which the water was admitted, and gives the thickening of the mesoderm by lateral growth as the immediate cause of the lengthening of the branches. This accounts for their length, but not for ampullae which must have been due to the localization of the gastric functions in these sacs when they were primarily developed as diverticula of the central gastric cavity. The thickening of the mesoderm and consequent elongation of the pores into tubes would naturally lead to the extension of the feeding cells towards the periphery along these tubes in the direction of the sources from which the food supply was coming. The dilatation of the branches and their adaptation for the interruption of the currents would follow upon the increased opportunities of the cells near the periphery and in these hollows to seize floating food, even if the form and size of the cells did not of themselves occasion an enlargement at the beginning of such a differentiation. We might thus account for the origin of the primitive diverticula as portions of a gastro-vascular system and their outgrowth as due to the prior formation of the tubes, but it seems as if still another cause should be considered as assisting in this process and possibly having even greater influence. The single ampullaceous sacs or diverticula being outgrowths or branches of the archenteron would, if not prevented by the thick mesoderm, force out the ectoderm and appear externally even in Sycones and Myxospongiae. This effect is displayed in the lower Sycones, which have lateral ampullae and a thin mesoderm. Sycetta primitiva (Haeck. Calcisp. pl. 41) and Sycaltis conifera (pl. 45) are species in which the growth of the ampullae carries out the thin walls so that each ampulla appears externally as a mamma-form projection. In the typical Sycones in which the mesoderm thickens these organs are proportionally buried until they are no longer apparent externally. One naturally infers, with Haeckel, that each ampulla was a bud equivalent to a complete Ascon, and that Sycaltis and the like were composed of as many "persons," as there were ampullae in the sponge and, therefore, that even those in which the ampullae were buried would have to be considered as colonies in the same sense. It harmonizes better, however, with the history of the development to consider these apparent buds as really localized extensions of the primitive central ciliated chamber of the ascon. The ampullae being derived from extensions of the smooth epithelium of the young cannot be estimated as primitive organs or as the equivalents of the gastrula. They are branches, diverticula, or organs, but not equivalent individuals, persons or zoons. Haeckel's view (Calcisp. p. 116–188), if we understand his comparisons, differs essentially. According to his theory a sycon is formed by strobiloid gemmation, and each radial tube is the equivalent of a "person" or an ascon, though he apparently takes the view that the ampullae are organs. To this illustrious auther true antimera do not exist in the sponges, whereas we find indistinct and primitive antimera in the ampullae. We cannot agree also with the result of his comparisons that the sycon and other compound sponges are to be defined as having the buds of the primitive colonial forms united so as to form an individual. This result and Haeckel's opinion, that the intermediate canals which are found in some sponges are due to the imperfect junction of strobiloid buds in the building up of compound forms, have been dissented from by Vosmaer. This author asserts (Bronn's Thierreichs, vol. II, Porifera, p. 136), that in no case does the surface of a Sycon grow out into buds, but that the tubes are bound together because they grow in the mass of the tissue. Vosmaer also describes the "intercanal system" as consisting of true lacunae which open as the mesoderm thickens, and cannot be considered as tubes left open by the imperfect junction of individuals, or the walls of the colony as in any sense due to infoldings of the ectoderm of the sponge. The gastrula, according to Haeckel, indicates, that a "person" is any sponge or branch of a massive sponge, which has but one cloacal aperture, whereas in our view the opening of the gastrula is not the homologue of the cloacal tube nor of a stomodeum. Any number of stomodea may exist in a sponge or any part of one, since they are merely primitive invaginations of the ectoderm without distinct localization in the adults, and subject to variation even in the young, though with a tendency in many forms to appear at the pole opposite the blastopore, and arising in the primitive osculum, or outlet of the gastro-vascular system.

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[1] Johnson's Encyclop. supplem. appendix, p. 1668, 1878, contains a statement of this result, but not of the reasoning which led to it.

If, as we suppose, the ampullae are antimera, homologous with the coelomic sacs of Hydrozoa, Actinozoa and Echinodermata, the theory may be of some value to general morphology as an explanation of the appearance of internal antimera, first as irregular and then as more or less regular abortive branches of the archenteron; their progress in regularity, radial or bisymmetrical, keeping pace with specialization of functions. Thus the process of invagination which begins with the gastrula, when continued causes the archenteron to branch, forming transitions to more complete spongozoons or individuals as in Sycetta and Sycaltis. The Porifera are not degenerative in any sense, but steadily preserve and differentiate the spongozoon or the primitive ascon type; through the tendency to a sessile life and the correllative thickening of the mesoderm they have retained the individuality of the form as completely as the Dendrocoela among Vermes. The branching of the central cavity is a marked progress in differentiation by which the outgrowths or secondary invaginations of the archenteron are converted into essential, specialized organs, the ampullae. Undoubtedly the branching of the archenteron, though not due to true budding, is distinguishable from the budding of an ascon, only by the fact that in the ascon all of the membranes take part in the formation of the new branch or spongozoon, whereas in the formation of an ampulla only the endoderm is the active agent, and when the other membranes take part, as in the Sycetta and Sycaltis mentioned above, no true buds are formed. The Porifera are likely to prove useful, not only in illustrating the primitive relations and origin of organs as diverticula, but also in enabling us to see that the morphology of the reproduction of individuals by budding, and of organs by invagination is capable of being followed to a focus where the separation of the two processes seems difficult both structually and physiologically.

The large vases which are built up by the growth of the peripheral parts of a sponge, as in Hircinia campana and all species which construct a general cloaca of this form, are extremely interesting in connection with general morphology. No one will dispute that these vases are undoubtedly lined by the ectoderm as may be seen by the series of transitional forms, and the color and structure of the internal layer. But we have been obliged to go farther than this and admit that the outer parts of the cloacal tube of any sponge having a smooth lining membrane cannot be separated from these cloacal vases. Thus the adult structure, histology and color of the lining membranes of the perfect cloacal tubes in Spongia do not permit us to imagine them as lined by the endoderm, and the same must be said of the incurrent system of superficial cavities and tubes. Vosmaer's results (Leucandra aspera, Leiden, 1880, pl. II, f. 3–4) show that he considers the supply system of tubes to be lined by the ectoderm in Leucones and Carneospongiae. Though he regards the lining layer of the excretory system as endodermic, his drawings, like those of other authors, fail to show histological differences between this layer and the ectoderm, both being composed of flat epithelial cells. So far as can be seen both the histology and the general aspect of these tubes give no support to the idea that any of them are lined by membranes which differ in any way from the ectoderm. This comparison of course includes only massive sponges, Leucones and Carneospongiae, and probably does not apply to any Sycones or to the primitive Ascones or to the ascon stage of development, or to the ampullae in any sponge. In all of these histology and morphology support the idea that they are lined by the endoderm. In the Ascones the ciliated cells of the endoderm come in contact with the cells of the ectoderm on account of the extreme thinness of the mesenchyme; and in the thickening of the middle layer which takes place in the more specialized forms, this border line of demarcation is perhaps approximately maintained in the incurrent and excurrent canals. That certain inner portions of the cloacal canals must be considered as lined by an endoderm seems probable from the structure of Sycones and the results of Marshall's and Schultze's work on the development of the central cavity in Reniera and Plakina, which shows that the archenteron is formed by epithelial cells; but that the outer parts of the cloaca are formed by invagination of the ectoderm as a result of peripheral growth seems also evident. The ampullinula, according to our view, shows that the limit of the extension of the endoderm is the primitive cloaca, as shown by Marshall, and that, contrary to what seems to be his opinion, it may prove to be the limit of its extension outwardly in older forms. There are no facts to show that the endoderm extends into the incurrent tubes beyond the ampullae, or what the limits are in this direction. We therefore provisionally assume, in accordance with Marshall's research, that the endoderm extends into the incurrent canals beyond the ampullae, because this view seems to be in accord with the general homologies of the coelomic system in other branches of the animal kingdom, and enables one to homologize the tubes in part at least with the tubes of Coelenterata and Echinodermata.

The possibility that the primitive cloaca may have owed its origin to the pressure of water accumulated in the interior of the ampullinula has been already advanced by Barrois, and this opinion is sustained by the vase growths above described. The cloacal tubes in adult sponges appear to be kept open by the action of the more or less constant outflow from the interior, and extra growth of the peripheral parts building up the vase or the cloaca is indirectly due to the same cause. It is difficult to imagine the primitive cloacal tube to be due to any external influences. If a gastrula is present, and the normal transformation of the blastoporic area and its collar or velum (Lankester) into an organ of attachment be also granted, then the breaking through of the orifice and the formation of the cloaca at the free end would be an inevitable result of any accumulation of water or fluid within. The orifice would be formed as a simple opening. The next step would be the invagination of the ectoderm which would arise as a secondary ingrowth. The aspect and structure of the layers in the peripheral cavities of Spongia leave very little doubt that the true ectoderm extends to a certain extent internally. The color and aspect of the ectoderm and derm in the superficial canals is often precisely the same as upon the exterior, and it is evident that these are formed by invagination or ingrowths of the ectoderm, though whether this layer extends inwards any farther or not, may be considered doubtful.

This view of the lining membrane of the canal does not agree with that of any other investigator, but the histological similarity of the lining membranes in the cloacal and supply systems or the series of transitional structures above given cannot be accounted for unless the true ectodermal cells can be considered as extending far into the interior in the cloaca, and also in the supply canals, at least in full grown specimens.

If our conclusion is trustworthy the invagination of the ectoderm in the true cloaca is an intermediate step towards the formation of a stomodeum, and from it we may possibly get a hint of the mode in which the stomodeum and proctodeum might have arisen from the simplest form of an enlarged intercellular pore. The pore having arisen by pressure from within, and as an outlet naturally enlarging beyond the size of the inlets, would form the primitive cloacal osculum of the gastro-vascular archenteron. When the mesoderm thickened and the outlets multiplied, the lip of the original outlet might become the limit of the true endoderm, and this would agree with the limits of the endoderm in Marshall's larva, and the limits observed in adult Ascones or Sycones. In other forms, however, purely mechanical outgrowths of the periphery of the upper surface would take place, and the vase form of cloaca arise, or when carried to excess the true tubular cloaca would appear also lined by the ectoderm. The continued inheritance of this ingrowth of the ectoderm, whether taking place in one way or another, and the inheritance of the tendency to form ingrowths which must surely follow in descendent species, would tend to produce just such organs as the invaginations which give rise to the stomodeum. This accounts for the origin of the stomodeum in the higher forms, as a blind pit in a suitable locality near the archenteron, though apparently at first entirely independent, and for its elongation in the proper direction and final opening into this cavity. As an ectoblastic invagination having these peculiarities it becomes impossible to account for them in the embryo unless the stomodeal pit was previously connected with the archenteron, or formed the outer part of a tube leading into that cavity. Otherwise we cannot understand its choice of a suitable location and its internal growth in an evidently selected and predetermined direction towards the archenteron.

The tubes which connect the ampullae or coelomic cavities with the exterior are true water tubes and are doubtless the homologues of the tubes which connect the water vascular or coelomic cavities in Echinodermata with the exterior. These last are, however, outgrowths of the coelomic sacs and may be considered as the homologues of the primitive tubes of the Porifera only so far as these are formed by the endoderm. These opinions seem to harmonize in the main quite closely with those of Dr. Sedgwick's (Quart. Journ. Micr. Sci., 1884, p. 63), but he seems to regard the pores and the formation of tubes as the result of the outgrowth of the diverticula, whereas among sponges the facts all seem to imply that the pores were antecedent and possibly had an influence in leading to the development of tubes and of coelomic outgrowths from the archenteron. This very interesting and remarkable treatise, however, shows plainly that the author saw the importance of the pores in the Porifera, and takes these and the internal cavity as a starting point for his homologies. He considers the nephridia of the higher animals and the excretory tubes of Medusae to correspond with the pores in sponges, and to have arisen during the differentiation of the gastro-vascular system from some such primitive forms as they now have in those animals. These tubes viewed as connected with the water vascular system suggest comparison with the excretory pores of the gastro-vascular system in the Medusae and Ctenophorae, and seem to support fully the homologies of Sedgwick (ibid. p. 63), but here again the limits of the endoderm are the indications of the extent to which the homology may be carried. If, as maintained by Sedgwick, the nephridia are generally formed directly from the coelomic sacs in Vertebrata and Invertebrata, the ectoderm not entering into their composition, and they may be considered as breaking through the ectoderm by resorption, it seems evident that the true homologues of these tubes in Porifera are only those parts of the incurrent tubes, which are also formed by the endoderm.

When viewed, however, as connected with the formation of pits and ingrowths of the ectoderm, this theory harmonizes with Dr. Sedgwick's hypothesis of the origin of the trachea only by admitting that the invaginations are results and not themselves primitive forms. The tracheal tubes, for example, are regarded by Sedgwick (ibid. p. 66) as distinct in origin from pores or tubes and as proceeding from pits in the ectoderm and also as arising primarily as water breathing organs. The poriferan theory carries this view back one step more to the possible origin of the pits as subsequent separations of the outer or ectodermic elements of the tubes, which arose in connection with the primitive forms or the gastro-vascular apparatus; thus, though denying the origin of the tracheae from pits in the skin of some primitive form, this theory grants that these pits were intermediate forms between true tubes and tracheae. The tracheae of Peripatus might thus be supposed to have a common origin with the incurrent tubes of Porifera and to have retained the original irregularity of their distribution to a certain extent. This would appear to be a natural corollary of our former statements, but as will be seen farther on it is not permissible in view of the probably homoplastic origin of the coelomic sacs, and the evidently secondary origin and late appearance of tubes and pores in the Coelenterata.

The embryos of Echinodermata, as may be seen by the publications of various authors (Mem. Mus. Comp. Zool., vol. IX, no. 3), do not close the blastopore, but this becomes converted into the anus, while the stomodeum is developed from a lateral invagination. This invagination is similar to the osculum of Porifera in the ascula stage in so far as it is not coincident with the blastopore and is ectodermic. The same homology seems to obtain in other types which close the blastopore and develope a stomodeum by an independent invagination as in Paludina, and Sagitta.[1] The ingrowth of the rim of the blastopore in Actinozoa to form an actinostome is, therefore, due to a fusion between the primitive stomodeum and the blastopore and not to any natural tendency of the blastopore itself to become invaginated. In other words the primitive stomodeum is not necessarily apart of the blastopore, but an independent invagination which may or may not coincide with it. Lankester's and Sedgwick's objection, that we cannot imagine the exchange in position of the posterior and anterior ends of closely allied forms which is implied in the theory of the independent origin of the stomodeum, does not seem to us well founded. There is no greater difficulty in admitting the exchangeability of characterristics in an antero-posterior, than in a transverse direction. The two ends in most embryos are quite as similar structurally as are the two sides, and an exchange is not at all incredible provided it is supposed as taking place either in embryo or in primitive undifferentiated forms.[2] According to Sedgwick's hypothesis (Quart. Journ. Micr. Science, 1884, p. 43) metameric segmentation as found in the Worms, Insects, Arthropoda and Vertebrata, arises through transformations in which the vertical antimera of the Radiata become converted into horizontal, bilateral somites. The theory is founded largely upon the elongation of the actinostome or mouth of the Actinozoa, and the differentiation observed between the anterior and posterior ends. The primitive actinostome is round in the young but elongated in the adults, and while the central parts are approximate and more or less adherent, there are tubes kept open at the ends, one of which is ciliated and used as a water tube, while the other has excretory functions. Sedgwick supposes that this differentiation is parallel with that which takes place in a more abbreviated form in the vertebrate embryos, when the medullary plate, which he considers identical with, and as an elongation of, the blastoporic area and primitively ectoblastic, arises, becomes invaginated, and forms the neural canal. The canal thus formed is supposed, when presented in this general way, to be the homologue of the actinostome, and instances are cited of its tubular connection with the mesenteron below in embryos and Ascidia. The posterior opening is supposed to be identical with the blastopore and to be connected with the formation of the anus, and an anterior opening as possibly present and bearing a similar relation to the mouth of the vertebrata.

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[1] See list by Balfour, Comp. Emb., vol. II, p. 281.

[2] If Van Wijhe's discoveries are sustained, this proposition will acquire additional support, and a basis for the theory of antero-posterior symmetry will be established equivalent to that which we now have for bilateral symmetry.

Prof. Sedgwick's hypothesis is fascinating and seems to be in accord with the general homologies between Radiata and Articulata, and also agrees fairly well with the mode of development of the coelomic cavities, whose paired symmetry is hard to account for on any other hypothesis. The author, however, insists upon the view that the stomodeum and proctodeum are necessarily derivatives of the elongated blastopore, whereas in sponges the evidence seems to be against this view; and, also, in other types in which the stomodeum arises as an independent invagination. Sedgwick's results with regard to the coincidence of the blastopore and the stomodeum and proctodeum have been denied by Dr. Kennel (Arb. Zool. Zoot. Inst. Wurzburg., vol. VII, 1884) after prolonged and profound investigations of the embryology and histology of Peripatus Edwardsii and torquatus from the West Indies. P. capensis, from Cape of Good Hope, was the species used by Sedgwick, and the differences noted by Kennel will probably be accounted for by concentration of development in the species he investigated; it seems evident, however, that the blastopore and the two invaginations referred to above are not necessarily coincident even in the different species of Peripatus. The results attained by Dr. Van Wijhe (Zool. Anzeig., vol. VII, 1884, p. 683) principally from the examination of the embryos of ducks are very important in this connection. He found that the neural canal communicated with the exterior by means of two pores, one at either end, and concludes that the neural canal was an organ through which water circulated, and thus explains the existence of ciliated cells in a part of this canal. Under the hinder "neuropore" lay the blastopore, and these two, fusing, produced the "blastoneuropore," which in turn closed after having built the permanent anus. The fore "neuropore" lay between the folds which form the primitive olfactory organ, and this he considers as indicating that the water must have entered at this pore and passed out posteriorly. Van Wijhe also quotes Hatscheck (Zool. Anzeig., 1884, no. 177) to show that the passage of water actually occurs through the ciliated furrow of the neural canal in the embryo of Amphioxus. Van Wijhe's results thus identify the olfactory pit, and not the stomodeum, as the probable invagination or vestibule which was primitively connected with the fore neuropore. One cannot read the researches of Dohrn, Balfour, Owen and Scott upon the origin of the olfactory invagination, hypophysis and stomodeum in Petromyzon (Balfour Comp. Embryol., vol. VII; Dohrn, especially Mittheil. Zool. Stat. Neapel, vol. IV, p. 172; also Scott, Morph. Jahrb., vol. VII, p. 158) without becoming aware that this result of Van Wijhe has in a measure confirmed the theory of Dohrn. It antagonizes that part of Dohrn's hypothesis which claims that the olfactory, hypophysial and stomodeal invaginations were derived from primitive gill slits which united to form central openings, and opposes to this view the very simple fact, that the olfactory organ must have been derived from a median tube. Dohrn seems on the other hand to have been the first to suspect that the hypophysis was the homologue of the oesophagus of some invertebrate ancestor of the Vertebrata, and Owen independently concurred in this view of its homology. This could only have occurred in a type in which the transfer of the respiratory function from the neural canal to the oesophagus was taking place, and suggests that a canal existed in the fore part of the animal into which this opened and which has been obliterated (Balfour); otherwise it is hard to give a reason for the absence of an anterior connection with the mesenteron. Dohrn seems to be sustained in his idea that the ectodermal invaginations are due to their former existence as parts of tubes which communicated with the interior; and this idea, though we were not aware of the fact previous to the writing of this page, is in large part parallel to that which we have applied to the explanation of the origin of the stomodea and the proctodea in the Invertebrata. Though too slightly acquainted with the embryology of vertebrates to venture a decided opinion, we can, in view of the extraordinary clearness of the evidence, suggest that these views and those of most writers are reconcilable on the basis of Dr. E. B. Wilson's late research upon the Actinozoa.

Prof. Sedgwick's theory has been supported by Dr. E. B. Wilson (Mitt. d. Zool. Stat. Neapel, vol. VII, p. 23), who goes a step farther and homologizes the cavity formed by the mesenterial filaments of the Actinozoa when feeding with the mesenteron of the embryos of Peripatus and Amphioxus. According to Wilson the mesenterial filaments or inner edges of the lower parts of the fleshy septa in the Actinaria and the six ventral filaments of Alcyonaria are laterally expanded and consist of feeding cells different from the smaller epithelial cells of the septal chambers. The large cells of the filaments are elongated and capable of intracellular digestion, and the smaller cells of the intermediate chambers never have inclusions, and are unsuitable for the performance of this function. While in the act of feeding the endodermic filaments, or those parts of them which are composed of endodermic cells, spread themselves out around the food mass and actually in some cases form a union, thus constructing a temporary mesenteron in which, however, intracellular digestion alone takes place. According to Wilson the dorsal filaments of Alcyonaria and the upper parts of those of Actinaria are derived from prolongations of the ectoderm of the actinostome and these are circulatory in function, and not to be confounded with the endodermic parts which are digestive. We have never been able to understand the validity of the objections to Prof. L. Agassiz's homology of the actinostome with the proboscis or hypostome of the Hydrozoa. It seems to us that the composition of its walls and the mesenterial filaments cannot be accounted for unless we admit their identity in both of these branches. The ectodermic origin of the numerous folds in the actinostome and the upper parts of the mesenteries, and their circulatory functions, described by Wilson, are apparently explicable on the supposition that they are similar to the fringes and tentacles of the actinostome (hypostome) in Hydrozoa. The comparison between the septal chambers and the coelomic sacs of the embryos of Amphioxus and Peripatus is rendered very complete, and even the mode of formation of the middle gut or mesenteron of the Articulata and Vertebrata is suggested by this remarkable investigation. By combining all the views which have been cited we can then understand Van Wijhe's two neuropores as corresponding anterior and posterior tubes belonging to the primitive neural canal, which would thus become homologous with the modified actinostome of some ancestor of the Vertebrata, the hypophysis and blastoneuropore as remnants of tubes which belonged to the period when the actinostome began to be divided from the region of the mesenteron below, but was still connected therewith. The stomodeum and proctodeum, however, would have to be considered as independent invaginations comparable with the similar ones in the Invertebrata, the former becoming the mouth and the latter fusing with the blastoneuropore and becoming the anus. When facts favoring the independent appearance of these invaginations in the Invertebrata are so strong, and the simultaneous presence of the three anterior invaginations in the embryos of Petromyzon, as given by Dohrn, is admitted, it certainly appears to be incorrect to allow oneself to imagine that any of them are necessarily derivatives of the differentiated tubes of the actinostome and necessarily parts of the blastopore. Hubrecht's homology of the hypophysis and the proboscis of nemerteans (Quart. Journ. Micr. Sci., vol. III, p. 355) and of the notochord, which is supposed to have been primitively tubular, with the sheath of the proboscis, if true, would make the presence of a vertical canal in the anterior end of the body unnecessary. In that case the hypophysis could be considered as connecting directly with the tube of the notochord (Lieberkühn, Archiv. Anat. and Physiol., 1884); with regard to this we do not feel able to judge, and Hubrecht's evidence seems to be too incomplete to form a reliable basis for decision on this point.

The difficulties presented by the posterior openings are apparently more serious, but probably these can be satisfied by means of the universal law of concentration in development. The external opening of the hinder neuropore in the course of these differentiations has become more and more narrowed or confined to what must be considered the posterior end of the neural infolding, and more liable to fusion with the blastopore and anus. Thus in some their development may have become really continuous, as claimed by Sedgwick, and in others discontinuous, as claimed by Van Wijhe; and yet in all cases no discrepancy with the history of the anterior openings in ancestral forms really exists. A parallel case is found in the fusion of the mantle invagination or sac of the Cephalopoda with the primitive shell gland. This takes place in the Sepioidea, according to Lankester, and we have in some measure verified his theory by the aid of Aulacoceras, a fossil form admirably described by Branco (Zeitschr. Deutsch. Geol. Gesellsch., 1880, p. 401) and whose occurrence in a measure was predicted by Lankester. This fusion took place by the earlier and earlier inheritance of the loose inclosing mantle sac of the Orthoceratite until it probably began to assume its more modern partly closed form in Aulacoceras of the Trias, leading into the completely closed form it assumed in Belemnites. In the Sepioidea it became entirely closed and inherited at so early a stage that the sac first became embryonic and finally fused with the shell gland, thus occasioning the permanent inclosure of the shell in these animals; whereas in the allied order of Belemnoids the shell probably was external in the young for an appreciable period, and the shell sac originated as a closed fold or invagination later in development and independently of the shell gland. This is also an interesting parallel with the formation of stomodea in the Porifera since it is at first an overgrowth or outgrowth of the mantle like that of Aplysia, and other similar cases among Mollusca, which becomes converted into a permanent invagination, thus giving another illustration of the theory here advocated of the origin of ectodermic invaginations as primitive outgrowths which have become transformed into invaginations of the endoblast due to the earlier inheritance of the tendency to extra growth on the part of the periphery. We have by no means intended in the above remarks to indorse the opinion that the coelomic sacs and tubes, or the neural canal and mesenteron of the Vertebrata were necessarily derived from some preëxisting ancestor among the Coelenterata. On the contrary we have used these comparisons between different but, as Cope would would call them, homologous forms (Origin of Genera, Proc. Acad. Sci. Philad., 1868, p. 53) to show that the Porifera, Coelenterata and possibly Vertebrata were derived from some common undiscovered form, possibly a gastrula, as parallel types and not as necessarily homogenous and diverging from a common, but nevertheless coelenterate ancestor, as seems to be Sedgwick's view. The comparisons made between Amphioxus and the Actinozoa are open also to the very serious objection, that, as shown below the coelomic sacs in the Actinozoa and Hydrozoa and Porifera are purely homoplastic organs arising from different structural modifications, from buds of the archenteron in Porifera and from vertical ingrowths of the endoderm in the Hydrozoa and Actinozoa. Thus the surroundings may be supposed to have produced a similar effect upon Amphioxus and the Ascidia; and the coelomic sacs and somites of the vertebrates, though strictly homologous derivatives of the archenteron, can be considered as entirely independent in origin from those of the Actinozoa, and possibly all other types.

The characteristics of the diverticula show that in the sponges these organs have a peculiar, and often dendritic distribution and primitive bag-like form, which afford strong contrasts with the same parts as they appear in the Hydrozoa and Actinozoa. Anatomically the sponges may be called Metazoa protocoelomata, and by the use of this term can be distinguished from the Radiata, or Metazoa trochocoelomata (animals having vertical and radiatory coelomata), and from the paired or yoked coelomates in which the metamera arise, as in Peripatus and Amphioxus, from bilateral diverticula. We can readily transform a protocoelomate into a trochocoelomate by destroying the horizontal parts of the partitions between the ampullae in a Sycones so as to resolve those sacs which lie immediately above each other in the same line into single cavities. This would transform a Sycon into an animal with a large number of vertical radiating chambers or antimera separated from each other by vertical mesenteries. Such a form would differ from a taeniolate Hydrozoon or a young Actinozoon in the histology of the lining membrane, since the chambers would be lined with the collared and ciliated cells and the septal edges would have a flat-celled, smooth epithelium. These histological differences, however, are adaptive peculiarities liable to variations between closely allied types like Ascones and Sycones, and also to great changes even in the same animal during the development of the individual. The smaller divisions of the Protocoelomata can be advantageously contrasted without unnecessary circumlocution by the use of similar terms. Thus we can term Ascones the Acoelomata in allusion to the pores and the absence of coelomata; and designate the Sycones as Syringocoelomata, or animals in which the next morphological differentiation takes place by which the diverticula of the archenteron extend themselves into the tubes leading to the pores: and lastly the Leucones and Carneospongiae, with their peculiar dendritic extensions of the same cavity, would become morphologically Dendrocoelomata, or branching coelomates.

The researches of Dr. Otto Hamann (Jena. Zeitschr., vol. XIV, 1882, p. 500) have shown that ridges or folds of specialized cells exist in the gastric cavity of the Hydrozoa, which can be compared closely with the septa of the Actinozoa, especially in the young of Actinia (pl. 20). The histology of the ridges is also sufficiently similar to that described by Wilson, in the septa and filaments of Actinozoa; and there is evidently in the Hydrozoa, as shown by Hamann's drawings, the beginning of a similar differentiation to that which exists in the Actinozoa between the digestive mesenterial filaments and the epithelium of the septal chambers. Prof. Mark has also published (Embryol. Monogr. Mus. Comp. Zool., vol. IX, no. 3) some remarkable figures of the fleshy septa in Edwardsia, which it is interesting to compare with those of Hamann's and Wilson's. The mode of growth of the mesenteries places an apparent difficulty in the way of the homology of the ampullae with the mesenterial chambers. These last are due to an ingrowth of the endoderm forming the dividing fleshy septa, whereas the ampullae are plainly outgrowths or invaginations of the endoderm. This discrepancy may be explained as a secondary mode of forming the coelomic sacs due to excessive thinness of the mesoderm in the Actinozoa. Instead of being steadily increased it becomes reduced in thickness, disappears almost completely and is reinforced by fresh epithelial cells arising from the ectoderm and endoderm, which form the secondary layers of the mesoblast or mesoderm of the Hertwigs (Jena. Zeitschr., vol. XIV, p. 19.). The wall of the archenteron, therefore, grows inwards and indirectly forms the coelomata by building the septal divisions, instead of growing outwards at special places and forming these pouches by the direct method as in the Porifera. Thus no pores appear in these young forms, so far as known, and they are certainly not essential structures in the Coelenterata. The structure of the archenteron and of the larva also, previous to the ingrowth of the mesenteries, and the extremely thin or absent mesoderm makes a close comparison possible between this form and the gastrula and Ascon stage of Sycandra. These facts and the thin middle layer and absence of diverticula in the adults of the acoelomate Ascones plainly indicate that we cannot assume the former existence of a poriferous ancestor with a thick middle layer or mesenchyme, but must necessarily picture the common ancestor of Coelenterata and Porifera as a triploblastic gastrula with a very thin mesenchyme and no pores. The assimilative and feeding functions of the endoderm in Actinozoa appear in strong contrast with the transference of the first functions to the mesenchyme in Porifera, but it must be recollected that this middle layer is very likely equally inactive as compared with the endoderm in the Ascones; and whether the next stage of the middle layer in Actinozoa is formed by epithelial layers split off from the ectoderm and endoderm, or whether it is developed out of the previously existing mesenchyme, it is evident that this layer has not the primitive importance in the Actinozoa and Echinodermata that it has in the sponges, and consequently more work is thrown upon the endoderm. The conclusion seems almost inevitable, therefore, that the antimera of Actinozoa and the ampullae of sponges, though formed from the same layer, are not homogenous but homoplastic parts arising independently in the two types from an ancestor which did not possess them.

The absence of incurrent pores in the Hydrozoa in connection with the gastric cavity, and the apparently secondary origin of the pores in connection with the coelomic sacs of many forms, especially in the Medusae and Ctenophorae, and the absence of the digestive ridges in the cavities of Campanularidae and Sertularidae, the Intaeniolata of Hamann[1] (op. cit., p. 509) are also favorable to our view. On the other hand Hydra, which has no digestive ridges, has an ovum surrounded by a horny case (Kleinenberg) which shows it to be an abbreviated stage of a gonophore and identifies this genus as probably a concentrated form of the marine Taeniolata of Hamann. This view (suggested first by Huxley, Anat. Invert. Am. Ed., 1878, p. 121) we have held for some time to be probable on the basis of general morphology, because, as shown by Kleinenberg, the hydra form is developed directly without any free moving planula stage. This is also Haeckel's theoretical position, which views Spongilla and other fresh-water forms as highly specialized on account of their distribution and liable to have "quicker" development of the earlier stages.[2] It seems probable, therefore, that the intaeniolate structure may exist not only as a primitive condition of the larva, but arise again at the terminus of taeniolate series in the specialized forms as one of the correllative characteristics of a highly concentrated mode of development. Such degradations are common in fossil Cephalopoda among highly specialized and concentrated forms with local distribution and in the distorted shells of the Steinheim Planorbidae. We have accounted for them by the sweeping away of the progressive characters in the young of the specialized degenerative forms. In the development of Hydra the fleshy septa, the gastrula, hydroplanula, free actinula and colonial form, have all suffered or been more or less suppressed by concentration, so that the degenerate hydraform has a direct mode of development from an inclosed planula by delamination. This is, also, approximately similar to the views of Balfour, though he makes his comparisons from the stand point of natural selection (Comp. Embryol., vol. I, pp. 127, 151.). A comparison of Ciamician's figures of the development of Tubularia mesembryanthema (Zeitschr. Wissen. Zool., vol. XXXII, pl. 18–19), with Kleinenberg's famous paper on the development of Hydra, enables one to see that the epibolic gastrula of the Tubularidae belongs to a very early stage of the ovum, and must have in some way become unnecessary to the abbreviated delamination by which the inner layer is formed in the young of Hydra.

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[1] Hamann quotes only Koch (Jena. Zeitschr., vol. VII) as having seen these ridges but in Parypha crocea (Agass. Contr. Nat. Hist. N. A., vol. III, pl. 23, f. 7), four are figured, and described as "semi-partitions?" in the text. Eucope polystyla, according to Kowalewsky (Embryol. Monogr. Mus. Comp. Zool., vol. IX, no. 3, pl. 3), and the young scyphistoma stage of Chrysaora, and the young of Actinia, Kowalewsky (ibid. pl. XI), are all described as having vertical septa.

[2] It is possible that this may have some bearing upon the extraordinary result of Gotte's research (Zool. Anzeig. 1884, p. 679) in which he has found that the ectoderm disappears and all three of the layers of this sponge are developed from the endoderm. Such an opinion, however, requires very strong support, since it seems at first sight entirely irreconcilable with other observations and implies that the sponges are disinct in their earliest stage from all other animals.

This result has not in the least surprised us since we have been constantly in the habit of finding homoplastic characteristics arising in similar parts of animals as closely related as two genera in the same family or forms in different families or orders of fossil Cephalopoda. So far, therefore, as the sponges and Actinozoa are concerned, purely mechanical reasons appear to be applicable to the origin of the diverticula. In the one case the pores and growth of the mesenchyme, in the other the ingrowth of fleshy septa. The phenomena in both cases, however, take place as a direct result of the extra growth of specialized assimilative cells and membranes, and the correlations seem to point to excess of nutriment as the primary cause; the excess being localized in the ampullae and mesenchyme of the Porifera, and in the taeniolate ridges, and endodermic mesenterial filaments of the Coelenterata. Paleontologists have been of late rapidly bringing forward testimony, as has Prof. Cope in several essays, that "homologous" forms may occur in parallel series which from this point of view can be called "heterologous" in their own series. Homology in other words signifies simply identity of position in relation to other parts, or other forms, and probably a common origin for the different series in which they occur; but these homologous parts and forms may very often be purely homoplastic in origin.

The development of the actinostome occurs late in the life of the Actinozoon (see Embryol. Monogr. Mus. Comp. Zool., vol. IX, no. 3), and there is no longer any doubt that this is an invagination of all the layers of the body at the rim of the blastopore.

During this process the blastopore is carried inwards and the internal opening of the actinostome thus becomes the homologue of the primitive blastopore of the hydroplanula, and also represents the external orifice of the body in the Hydrozoa. This gullet-larval, or gulinula stage, as we propose to call it, is additional to the tentacular stage, which has in Hydrozoa been called the actinula,—but occurs in point of time and succession in the Actinozoa between the earlier gastrula or planula, and the later tentaculated stage. This succession indicates very clearly that the tentaculated stage of Actinozoa is not homogenous with the actinula of the Hydrozoa, as indeed has been probable ever since the discovery of Protohydra and the noticeable correlation of this form and the adolescent larva of the marine Hydroida. Both agree in being hydras without tentacles and almost conclusively show that the primitive ancestor must have been similar to Protohydra. Thus we have to consider the hydra stage as greatly abbreviated in the Actinozoa, or not represented at all in many forms, and all later stages than the planula are probably homoplastic and not homogenous in their relation to the Hydrozoa. The Actinozoa and Hydrozoa, in other words, differ in the succession of their stages of growth, and there is an interpolation of new stages in the Actinozoa which can be accounted for only on the supposition that in these types the tentacles, the actinostome, and the mesenterial filaments are not inherited from the simpler Hydrozoa, but originated independently in the Actinozoa. The pores, also, which arise late in life in Actinozoa and are not found at all in many forms of Hydrozoa, must have been independent in origin like the actinostome.

This actinostome, though an invagination in the embryos of existing Actinozoa, was evidently not subject to invagination in primitive forms. The mode of formation of the Actinostome by invagination may therefore, in accord with our theory, be supposed to be secondary and to have arisen through peripheral outgrowth of the parts around the mouth. This would have caused the actinostome first to assume the form of an inverted funnel lined by the ectoderm, and finally have led to the introduction of invagination. The formation of an invagination homologous with an actinostome occurs in Cassiopea, but very late in the life of the larva after it becomes attached (Kowalevsky, Soc. Friends

Nat. Sci. Moscow, vol. x, pl. 2, f. 11). This stage is preceded by one in which the larva presents an elongation of the body and a narrowing of the aperture into a semblance of a "hypostome," in apparently close accord with this theory.

Even the facts we have cited above in favor of the homology of the fore and hind neuropores with the fore and hind openings of the actinostome seem to have a similar meaning, since the simultaneous occurrence of other invaginations in Petromyzon shows that some azygos openings must have arisen independently in the Vertebrata, and are not derivatives of the fore and hind neuropores or of similar openings in the body of a coelenterate ancestor. This is one view, but still another may be taken based on facts tending to show that the neural infolding is itself not the homologue of an actinostome. The archenteric mouth of Peripatus capensis, and the neural invagination of Vertebrata and its appearance after the blastopore, and anterior to the primitive streak, appear to favor this view; but on the other hand the medullary plate and fold in Ascidia and Amphioxus appear on what must be considered as the dorsal side of the planula, and the blastopore is inclosed and transformed into the posterior neurenteric canal.[1] It may be said by objectors, therefore, that the neural groove must have occurred primitively on the dorsal side, and that the neural groove is not an actinostome at all, but a dorsal fold closed off from the mesenteron by the external wall of the body; and this is why the blastopore is situated posteriorly.[2] The presence of a fore neurenteric canal may be assumed as has been done by Balfour; but it must be confessed that the moment one takes this position the whole homology of the neural fold and actinostome assumes a doubtful aspect, and it is at once apparent that an imaginary fore neurenteric canal is a necessity of the theory, since otherwise there is not exact correspondence between the parts of the neural invagination and those of the actinostome. It can be claimed with reason that no such canal exists in the embryo, and cannot be expected to occur; and that it is perfectly consistent with the general structure and mode of formation of the neural infolding and of the chorda dorsalis, that none should exist. The extra growth of the ectoblast on the ventral side turns the blastopore dorsally. The first aspect of the medullary groove is an invagination leading to the blastopore; and the folds, according to Kowalevsky, arise on either side and from behind the blastopore forming a part of its border. They then grow forwards extending into a groove which is subsequently closed by the junction of the posterior parts over the blastopore, and the progress of this junction is carried forwards until only a small anterior orifice is left (Arch. Mikr. Anat., vol. 13).

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[1] Hatscheck (Arb. Zool. Inst Wien, vol. IV) distinctly calls the flattened side the dorsum, and gives very nearly the same account as Kowalevsky of the transformations of the embryo of Amphioxus; and also fully supports Kowalevsky's statement of the mode of inclosure of the blastopore.

[2] It is interesting in this connection to note that Kupffer in his article Die Gastrulation etc (Arch. Anat. et Physiol., 1884) seems to show in the clearest manner by his sections the solitary origin and exclusively posterior location of the blastopore.

This looks to us like the formation of a primitive stomodeum by an outgrowth of the circumoral parts; and the elongation of the cup-like stomodeum into a groove could easily be accounted for as due to the need of a respiratory and vortex producing trap-like vestibule, which might be at first open and then closed, but not necessarily having any *anterior* connection with the archenteron. Thus the neural canal does not necessarily represent an actinostome at all, but a primitive invagination, becoming a fore and aft tube by the elongation of the body, and the necessary transference of the principal opening to the forward end of the same body.

Hubrecht's and Lieberkühn's opinion that the hypophysis was the vestibule of a hollow notochord may be used to show that this is the representative of another fore and aft tube, which has arisen from the archenteron. Whether this can be considered as indicating a vermian ancestor for the Vertebrata (Hubrecht), we cannot discuss in detail; but we are not aware that any invertebrate embryos exhibit organs which can be considered as homologous with the medullary plate and groove. Until such characteristics are exhibited, the positive data afforded by the succession of characteristics during the development of Ascidia and Amphioxus are decisive against any supposition that the notochord could have occurred in the evolution of the phylum before the medullary plate and fold. The ancestors of the Vertebrata must have acquired their characteristics in some succession, and that succession is plainly recorded in the embryos of the forms mentioned. The notochord, whether primitively a tube or a solid mass of cells, arose according to Kowalevsky after, and not before, the canal.

Such facts as these and the primitive nature of the medullary folds, which appear at first as mere outgrowths like a primitive stomodeum, seem to indicate a homoplastic origin for the essential organs and stand in the way of choice of any known type of invertebrata for an ancestor of the vertebrata. One readily sees how the mechanical requirements of an elongated body might lead to the formation of the medullary plate, and it also opens the way by which it is possible to account for the conversion of the upper part of the mesenteron into the hypophysial tube and finally into a notochord, simply because of the need of a stiff axis to strengthen the neural fold. Possibly the formation of the former may be traceable to reactions of the axial portions caused by the action of the lateral myoblasts in moving an elongated vermiform animal with two regions divided from each other by a longitudinal tube. According to the well known laws of use this tube would be forcibly acted upon by these muscles and react by growth against them, tending continually to become solidified and more resistant.

This view accords with Cope's explanation of the distribution and formation of the neurocentra, pleurocentra and neurapophyses in the vertebrae of the Permian Rhachitomi. This author with his usual clear insight has illustrated the segmentation of these primitive vertebrae by means of the folds which occur on the inner side of a coat sleeve when compressed by the bending of the arm. We find ourselves also in accord with Spencer, who first suggested the segmentation of vertebrae to be due to lateral flexion (Prin. Biol., II, p. 195); and with Ryder in his last remarkable treatise on the mechanical evolution of the different forms of the tail in fishes. Our hypothesis simply completes their explanations by attributing the origin of the notochord itself to the same causes which have probably occasioned the subsequent segmentation of the calcareous plates, and the inequalities of the tail.[1]

We think, also, that the evidence is very deficient for the accepted belief that the Ascidia have degenerated widely from their original stock form. The Porifera in relation to the Coelenterata have been generally considered degenerate, and yet there are strong reasons against this opinion; and the Ascidia seem to us to bear a somewhat similar relation to the Vertebrata. Their embryonic history has no stage which exhibits, as does that of Cirripedia and many parasites, a distinct type-larval stage by which we can definitely show that they are degraded forms of a vertebrate type higher than Amphioxus. If the Ascidia are admitted to be Vertebrata, it is evident that they must have sprung from some lower type than the Amphioxus, and one in which the formation of a notochord was in a still more immature condition. The tail and its four muscles, though hard to account for, unless the Ascidian is a vertebrate, are the highest characteristics shown by the embryo; and these do not bespeak any origin more exalted than that of some type considerably less differentiated than Amphioxus.

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[1] We have found, too late for insertion in this page, that Spencer has completely anticipated this theory. (op. cit. p. 199.)

The formation of the lateral muscles from lines of cells derived from the lateral walls of the archenteron, as shown by Kowalevsky, is a case of direct conversion, and it remains to be determined whether these myoblasts can be considered as representing archenteric diverticula. Similar conversions occur in Cassiopea (Kowalevsky, Soc. Friends Nat. Sci., vol. x, pt. 2, pl. 2, f. 8–10), and yet these myoblasts are not diverticula, nor are the muscles so considered in other types when derived from the endoderm. Dohrn (Ursp. d. wirb. Thiere, Leipz. 1875) supported the theory of degeneration with strong arguments, but these are taken from comparisons of the later stages of growth in Ascidia with the adults of Cyclostomata; and, if there are fundamental differences in the embryo, as suggested by Kowalevsky, they serve to show the affinites of Ascidia with vertebrates, but not that they are degenerate descendants of Cyclostomata, or even of Amphioxus. Dohrn's law of the development of latent functions can be applied whether the changes are degenerative or progressive. It seems to fully account for the transmutations of structure which occur in the Ascidia, but this point is not essential to the present discussion.

We may assume, if we choose, that the Ascidia are degenerate as regards some free moving ancestry, but the Porifera are degenerate in this respect, and so are all attached animals from the nature of their habitat and habits. The original stock forms of the different branches of the animal kingdom probably possessed gradation and taxonomic rank, and we are at liberty to infer that the Hydrozoa sprang as a division, or had a starting point from animals of the original stock which were taxonomically higher or more specialized than those from which the Porifera were derived; and possibly the Vertebrata may have sprung from some type higher in zoological rank than the ancestor of the Coelenterata; but we know very little about this orignal stock, and can only infer from the embryos of animals that it must have contained forms, as stated by Haeckel, in some way similar to the gastrula and planula; farther than this there appears to be no solid ground for inference. Thus in the Ascidia as worked out by Kowalevsky (Arch. Mikr. Anat. vol. VII, 1871) and other authors, there are, so far as we know, no sufficient grounds for imagining that any ancestor of this division possessed coelomic sacs or diverticula of the archenteron. The cavity of the body in the adult is emphatically declared by Kowalevsky to be continuous in its history with the primitive blastocoel: "bei den Ascidien die Leibeshöhle doch aus der Fürchungshöhle abstamme." It is evident, therefore, that no argument for a coelenterate ancestor can be based on their structure in embryo or adult. Thus then, as the evidence now stands, the coelomic sacs in Amphioxus must have been derived from some higher type than Ascidia, — and probably, therefore, were not present in the original ancestral vertebrate type, which must have been more nearly related to Ascidia than it was to Amphioxus. Balfour's idea that the Ascidia were more modified in their development than the Cephalochorda, or Amphioxus, was doubtless due to the fact that he compared the embryos with the vertebrata rather than with invertebrata; whereas, according to Kowalevsky, they have no coelom at any age, and in this respect approximate the invertebrats more than any form of vertebrates. They resemble, in their relations to higher forms of their own branch, the Ascones among Porifera and the Intaeniolata among Hydrozoa, which also have no coelomic sacs at any stage.

The difficulties included in the view that the planula and gastrula present separate and original modes of developing the endoderm is admirably put by Balfour, who shows that this implies two distinct ancestral types for Hydrozoa, and that either the planula or gastrula, therefore, must have been a secondary or derivative form. By far the best and most complete analysis of, this difficult problem is given by Dr. Whitman (Embryol. Clepsine p. 300), where the author concludes that delamination is the secondary, and gastrulation the primitive mode of developing the endoderm, and also in large part anticipates the views advocated in this paper with regard to the origin of gastrular invaginations. When the gastrula and planula are found together, as in the Acraspeda, the gastrula procedes in development the planula (Claus, Polyp. Quall. Denk. Akad. Wien., vol. XXXVIII, 1877 Balfour, Embryol., vol. I, p. 137; and Alex. Agassiz, Embryol. Monog. Mus. Comp. Zool., vol. IX, no. 3, pl. 7); and this planula is really a three-layered mouthless sac in Chrysaora, but, through the suppression of the primitive mesenchyme of the parenchymula, it subsequently has the aspect of being only a two-layered hydroplanula. Among the Actinozoa it seems evident that the gastrula, often composed of primitive and amoeboidal cells, is an earlier condition of the ovum and leads to the formation of the hydroplanula which retains the blastopore as its mouth, as shown by Kowalevsky in Actinia? (Embry. Monog. Mus. Comp. Zool., vol. IX, no. 3, pl. 11, f. 27–29).[1] The tacit assumption that the planula was necessarily a mouthless form and preceded the gastrula, was due to the resemblance between the hydroplanula and the parenchynula which are often considered identical and confused with the true planula. The figures of Cerianthus membranaceus, also from Kowalevsky (ibid., pl. XII, f. 1–6), is presented as the next stage after the blastula, and compare closely with the similar period of the parenchymula in the sponges, which also in Halisarca precedes in development the permanent gastrula. The gastrula in Cerianthus, also, immediately follows this stage and becomes an elongated hydroplanula with a persistent blastopore. From our point of view the single layered embryo (f. 1) is a parenchymula in which the mesenchyme is absent or has not been observed (a frequent occurrence among sponges on account of the transparency of the layer or some defect in observation), the true hydroplanula is the apparently two-layered form immediately succeeding the gastrula (f. 3); but both parenchymula and hydroplanula are probably much abbreviated.

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[1] The originals of these and other figures, quoted from this author are to be found in Memoirs, vol. x, Imperial Soc. of Friends of Nat. Sci., Anthrop., and Ethn. Moscow, no. 2, 1874; and the text has been translated for the author by the kindness of Miss B. F. Hapgood.

The difficulties presented by the change from invagination to delamination have been met by Lankester with the aid of hypothetical molecules of protoplasm respectively called deric and enteric, which were supposed to have acquired the developmental tendencies of the primitive membranes in which they originated. Thus the gastrula was imagined to have become changed by abbreviation of development into the planula, and this process was supposed to have been rendered possible by the existence of peculiar endoblastic, enteric molecules, which were finally transferred by these changes from the separate cells of the endoblast in which they arose to the inner poles of the primitive ectoblastic cells of the planula.

We should prefer to seek for the solution of this problem in the relations of the planes of fission to the axes of the body, or of the cells themselves. The planes of fission by which the cells of the endoblast in the amphimorulae of Porifera are differentiated may have been parallel with their longest axes, or more or less inclined to them, but were probably not transverse. On the other hand the planes of fission in the delamination of the mesenchyme cells habitually appear to be transverse, and in Geryonea (Fol) and in an unpublished plate of the embryo of Eutima by Prof. W. K. Brooks equally decisive cases of delamination of the ectoblast by transverse fission occur.[1] In all instances the first stage of differentiation by fission would necessarily result in the formation of an endoblast, and it is quite within the limits of possibility that extra growth or quicker and earlier growth of the ectoblast may have been the immediate cause of the origin of the endoblast from the inner poles of the ectoblastic cells by transverse instead of by radial fission.

This explanation we rejoice to notice has been anticipated by Dr. C. O. Whitman (op. cit., p. 303), so far as relates to the formation of the gastrula, and this gives us necessarily greater confidence in its general application to the origin of invaginations. Whitman's remarks are as follows: "Starting with a typical blastula it is not necessary to assume that unequal growth would always result in invagination; but it is easy to see that the more rapid growth of one hemisphere, accompanied perhaps by an absorption of the blastocoelic fluid, might lead to a double-walled gastrula."

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[1] See also Zool. Anzeig., 1884, vol. VII, p. 709.

This hypothesis acquires support from the researches which have been so far made into the direction of the planes of fission. Dr. Arthur Kollmann in his treatise (Der Tastapparat der Hand, etc., Leipzig, Voss, 1883) has announced an important law of fission. Thus in the development of cells in the epidermis when the predominating planes of fission are at right angles to the axis and to the surface of the body, the epidermis increases in length; whereas, when the somewhat rarer form of cell division (in which the planes of fission are at right angles to the surface, but parallel with the long axis of the body) occurs, the same membrane increases in breadth; and when the planes of fission are parallel both to the surface and to the axis of the body the epidermis increases in thickness. The same author also shows that the epiblast in the neighborhood of the primitive streak consists of elongated cells. These give rise to the primitive streak below, and the cells change in form; those above being subject to considerable lateral pressure are elongated while those in the primitive streak vary, being often cuboidal. Finally, however, these become similar to the forms from which they originated when in course of growth the same influence is again brought to bear upon them. Dr. E. G. Gardiner, to whom we owe the suggestion as to the correspondence of the modes of division and forms of cells, and the direction of the pressure (Beit. Kennt. d. Epitrich. Arch. Mikr. Anat., vol. XXIV, 1884) has shown that the cells of that part of the epiblast which is destined to form the medullary canal of the embryo are at first cylindrical cells, because of the lateral pressure of the epiblast; but towards peripheral parts where the activity of the fission, and therefore pressure, is much less, the cylindrical cells are replaced by cuboidal cells. At a later stage, after the medullary canal is closed, the rapid development of this part exerts such a pressure upon the superimposed epiderm that the cells become flattened and form only a single layer. The same is true of the cells of the epiderm immediately above the equally active protovertebrae, while between these places where growth and pressure are less the epiderm consists of several layers. A corresponding transference of the planes of fission from approximately vertical diagonals to approximately horizontal diagonals is also figured in the same treatise. It is evident that the planes of fission of the amphimorula must have been radial or perpendicular to the surface, and perpendicular and parallel to the long axis of the body; thus being in accord with Kollmann's law in so far as the result is an increase of the body in length and breadth. On the other hand delamination is an increase of the ectoblast in thickness and here again we find the planes of fission parallel both to the surface and to the axis of the body also, agreeing with Kollman's law.

Kollmann's and Gardiner's results are pertinent and can also be applied to explain the transformations of the epithelium in sponges. The cells of the ectoderm in Porifera pass through the amoeboidal, wedge-shaped, columnar, and cylindrical forms. During the last two stages they acquire flagella and collars in most forms, but finally terminate in an epithelium of flattened cells. The major axes of the cells are shifted from a radial in the segmental wedges to a tangential direction in the flat epithelium, and in each case they are at right angles to the direction of the pressure due to growth of the neighboring cells. The excess of growth in the embryo is invariably in the ectoblastic layer, and this occasions the flattening and radial elongation of the cells in this membrane until the completion of the cinctoplanula stage; then the excess of growth is transferred to the mesenchyme and this increasing in thickness causes the flattening of the cells on the exterior in the older stages. The Ascones have an exceedingly thin mesoderm, but nevertheless an ectoderm is present of excessively flattened cells. No one, however, can study this in living specimens without seeing that considerable pressure is exercised by the stiff spicules which support the body, and that these parts must be taken into the account of the causes which may occasion the flattening of the outer layer. The functions of assimilation being maintained by the endoderm throughout life in such forms as Ascones, the cylindrical cells are retained also, together with their hereditary protozoonal collars and flagella, even in adults. When, however, the function and pressure are transferred to the ampullae, as in Sycones, we find that flattened cells appear in the archenteron and the elongated cells are present in the ampullae. It may be inferred, though direct observation is needed to prove the facts, that the effects of use in catching and assimilating food restore the collars and flagella and occasion extra growth and pressure in the bodies of the cells. The theory accounts for the restoration of the elongated forms of the cells and the radial direction of the axes as well as the fact that the imaginary centre instead of the centre or central axis of the body as in the embryo and in the long body of Ascones, is now the axis of the ampulla. The axes of the cells in the gastrula are at first elongated and radial as shown by Schultze in Sycandra, but in this form and in the larvae of Carneospongiae as mentioned above, they apparently lose their flagella, collars and elongated forms in the archenteron, and pass through an epithelial stage; though possibly such a stage may not be present in some of the Ascones. This change seems at first sight opposed to the theory of pressure, but until we know what conditions surround these cells in the archenteron of the ascula we cannot say whether the advent of epithelial cells is due to heredity or to the cessation of the nutritive function and a consequent relief of pressure during this stage of growth. The mesenchyme maintains the globular amoeboidal form in all its cells, except in those near the ectoderm and endoderm. These becoming in part subject to the same pressure as the cells of the ectoderm and endoderm are also in the same degree transformed into membrane cells, and this theory derives additional support from the fact stated farther on, that in Spongilla the inner sides of the dermal cells are flat and the outer sides alone exhibit the capacity to expand and become globular. The general morphology, observed movements, and the granular contents show that the cells of the mesenchyme are probably the active agents of growth, and the immediate causes of the pressure, which is apparent in the shapes of the ectodermal and endodermal membranes. It still remains to be shown in accordance with the theory that these cells have different modes of division in correlation with the pressure exerted; but with regard to this point we have no evidence of any value. The researches of Haeckel and Saville Kent have shown that the cells of the endoderm are subject to degeneration when taken out of their places in the membrane, and are apt to lose their collars and flagella, and become amoeboid. We have not, in these remarks, any intention of denying the effects of heredity. The protozoonal characteristics, the collars and flagella, are in no way, that we can see, necessarily the products of the mechanical conditions of pressure like the forms of the cells; these exhibit the effects of heredity and continued use as plainly as any of the organs of higher animals. Lieberkühn (Müller's Archiv. Anat. Physiol., 1856, p. 11) describes three layers in the larva during the flagellated stages. An "Epiteliumschicht" of rounded amoeboidal cells with single flagella. He here notices a fine and suggestive distinction between the primitive freedom of the cells in this outer layer and the condition of closer attachment prevalent in more mature membranes. The "Corticalsubstanz" lies next to this internally, and consists of a jelly-mass with scattered, fatty granules; he also stated that the cells in this when freed by dissection have the amoeboid motions, since described by Haeckel and others, in the free cells of the mesoderm of sponges. The Corticalsubstanz occupies the centre of the embryo and has a spheroidal form, according to Lieberkühn. One cannot read this, and the descriptions of the feeding cells (p. 497), and of the ampullae and true cell membranes which he mentions (p. 498) as occurring in the tubes and upon the whole exterior of Spongilla, and the descriptions of amoeboid cells, their movements and granular contents, without seeing that the author had succeeded in optically distinguishing the ectoblast, mesenchyme, and endoblast in the larva, though unaware of the meaning and importance of his observations and not emphasizing these discoveries. This remarkable investigator fed the Spongilla with carmine and found that the grains were carried into the ampullae, which were situated in the axis of the tubes (one in each tube), that the grains remained in these sac-shaped organs for a time; and that while a part were passed on and out of the cloaca, another portion remained, having been swallowed by the cells of the ampullae.[1] Carter, in the same year and independently of Lieberkühn (Ann. Mag. Nat. Hist., 1856, p. 242; and 1857, vol. xx, p. 21), repeated these observations, described and figured the "ampulla" and asserted that the cells of the "ampullae" alone swallowed the grains of carmine. He mentions in the same magazine (vol. vi, ser. 4, 1870, p. 330), that the cells of these organs become loaded with carmine, and that after feeding the sponge closed the incurrent and excurrent orifices for a time, and when these were again opened the excrements were abundantly ejected. In 1871 (ibid., vol. VIII, ser. 4, p. 6) this close observer confirmed Clark's opinions with regard to the existence of the collar, using, however, Sycandra (Grantia) compressa instead of Ascaltis. The inclusions of indigo and carmine by the flagellated and collared cells of the ampullae were observed in this species, but the apparent digestion of the food, as described by Clarke, was not mentioned. Clarke in his article on the "Affinities of Spongiae Ciliatae" (Mem. Bost. Soc. Nat. Hist., 1868, vol. I, p. 325) states that he saw the particles of food carried down into the collars of the ampullaceous cells of Ascortis fragilis (Leucosolenia botryoides), and observed particles of food in the interiors of these cells apparently in different stages of digestive decomposition. Saville Kent's descriptions and figure of the manner in which Monosiga gracilis (Man. Infus., vol. I, p. 327, frontispiece) feeds upon carmine is a fine piece of work and very instructive in this connection. He shows, in this and also other allied forms, that the collar, which is largely developed, becomes an organ for gathering the particles of floating carmine, which travel up its sides and from thence into the interior where they are swallowed, and reappear in the body of the zoon as globular masses inclosed in vacuoles and undergoing the process of digestion. With such a result before one's eyes it becomes very difficult for an unprejudiced observer to refrain from concluding, that the function of the collar is similar in the ampullaceous cells of Porifera and in Protozoa.

The researches of Metschnikoff (Zeitschr. Wissen. Zool., vol. XXXII, and of Von Lendenfeld (ibid., vol. XXXVIII) naturally excite admiration, but even these cannot be considered as resolving all doubts, especially when Von Lendenfeld and Polaejeff take the extreme ground that the ampullae are solely excretory organs. Von Lendenfeld observed that the cells of the supply system, and those of the ampullae took up the grains abundantly, which, however, they soon after ejected unaltered; and though not as abundant, the grains of carmine were also present in the cells of the lining membranes of the cloacal canals. The cells of the lining membrane of the tubes of the supply system, must have passed the grains of carmine on to the cells of the mesoderm, because the amoeboid cells of the mesoderm in the immediate vicinity of the flattened epithelium of the supply canals were loaded with grains of carmine, while others more centrally situated were clear. The first named transported the grains through the mesoderm wandering to the neighborhood of the ampullae, and the contents became more or less rounded during this process. Von Lendenfeld, therefore, very naturally supposed that the office of the membrane cells was ingestion, that of the wandering cells of the mesoderm digestion and assimilation, and that of the ampullae excretion.

We have had excellent opportunities for watching the surfaces of the canals in living specimens of Chalinula arbuscula, and never saw anything akin to excretion in these or in the cells of the ampullae. The granules, which were abundant and highly refractile, may have indicated, as stated by Dr. Arnold Brass, the presence of nutritive matter; and their abundance in certain cells of the derm and mesoderm seems to support this supposition.

The lining layer in the supply and cloacal canals was in all its characteristics the equivalent of the ectoderm; it was a thin epithelium, with more or less fusiform or irregular cells, which were hardly half the size of the mesoderm cells in living specimens and very liable to destruction by rough handling. Thus it often occurred, that the mesoderm cells lying under them, and forming a dermal layer of greater or less thickness, or of only one layer of cells, were uncovered and seemed to replace them. In one specimen the centres of the cells of the endodermal layer were slightly swollen with contained granules, but this was evidently exceptional and not a normal condition.

The cells of the ectoderm were faithfully studied while living, and their contents noted in Ascortis fragilis, Halisarca Dujardinii, Microciona prolifera, and several species of Halichondria and especially in Chalinula arbuscula. The coarsest and thickest cells occurred in Halisarca, but even here the outlines were more or less angular, and the membrane was a single layered epithelium, such as has been described by Schultze and others. No inclusions of food were seen in any case examined by us, nor have any been figured, so far as we have seen, by others. In Chal. arbuscula from Annisquam, Mass. (Sci. Guide, no. III, f. 2) where these cells were constantly under observation for several months, nearly all possible outlines were seen in different parts of the ectoderm; but they remained always angular and flat, or if swollen were barely convex and did not present the globular expansions of the outer surface once seen in the cells of the endoderm. The ordinary shape was fusiform, and usually the interior was clouded more or less with granules collected in two crescents around the poles of the nucleus. In this respect, however, there was no invariability since we have seen unquestionable ectoderm cells absolutely filled with highly refractile granules; but the nucleus on account of the flattened form of the cells was never obscured. Keller's drawings exhibit the usual aspect of the ectoderm in dead specimens, but they are not in all cases so clear in the living, especially in the vicinity of the nuclei. Metschnikoff (Quart. Journ. Micr. Sci. Jan. 1874, translation) declares his opinion, derived from experiments with Ascetta primordialis and the embryo of Halisarca lobularis, that the ectoderm is not instrumental in the ingestion of food; and (though Von Lendefeld entertains doubts on this point as we have quoted below), most observations appear to sustain this conclusion.

The cells of the ampullae had the usual form, but my drawings give no observations of value, except that in living specimens I never saw any accumulations of an excretory nature in the ampullaceous chambers. The cells contained also an abundance of refractile granules.

The cells of the derm (Sci. Guide, no. III, f. 2, 14–18) varied from transparent and flattened, with fusiform outlines in Chal. arbuscula, to opaque cells distended with highly refractile granules. The former were constantly contracting and expanding without, however, leaving their places in the derm, and they lost their usually fusiform outline only in extreme cases when forming part of some thread-like extension across a tube.[1] In one specimen some of these cells around a narrow tube were elongate-fusiform while others had the usual shape. The globular cells when loaded with granules were always quiet, the central parts of the outer sides swollen into projecting globes, and the periphery of the upper sides only slightly convex. The outlines were fixed, fusiform, and their bases were flat on the inner sides.

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[1] These were the only cells found which could be described as possible muscular elements; but as in all others examined by us in the mesoderm they were capable of slowly but constantly changing their forms, and seemed to possess considerable powers of adhesion to each other as if connected by bands. The nuclei were never modified, but remained rigid causing the centres of elongated cells to stand out in minute prominences. There were no grounds for the supposition that these or others observed were muscular cells.

The cells in the interior of the mesoderm were either coarsely granulated, and globular or more or less flattened and clear. The former when compressed showed a nucleus as a slightly clearer central spot, but the clear cells had visible nuclei and nucleoli of large size. No movements or changes of form were observed in these cells, and they were never so regular in outline as were the cells of the ectoderm and endoderm, from which also they were easily distinguished by their large size. There were evidently but one class of cells in the mesoderm, which might differ in shape according to the quantity of granules they were carrying, or in size in some parts. The specimens examined had invariably passed through their reproductive periods, and all our observations were made with the view of studying the histology; thus no efforts were made to observe the effects of feeding by direct experimentation. The distinctions which have been drawn between the functions of the collared and flagellated cells in the ectoderm of the embryo, and in the ampullae of adults, are purely physiological, and histologically these membranes appear to be very similar.

The morphology of the central cavity and its membranes is also opposed to the opinions of Von Lendenfeld and Polaejeff, that the ampullae are exclusively excretory. Most spongologists will probably admit that the collared and flagellated cells of the central cavity in the adult of Ascones and the ascon stage of the larva of Sycones are feeding cells, and that in the Carneospongiae and Leucones the ampullae are localized branches of this cavity, lined with similar cells and standing in similar relation to the inflow of water and food through the supply canals. However willing to grant, therefore, that these ampullae might have functions of excretion additional to those they probably possessed in Ascones, the facts do not justify the conclusion that that their collared cells are not also true feeding cells.

Whatever the result of future research, it is evident, from the evidence above given, that the tissues in sponges are as primitive as their forms and general structure, and that from all points of view they exhibit no traces of derivation from any higher source than the colonial Protozoa. Von Lendenfeld, though claiming the sponges as properly belonging to the Coelenterata, entertains a similar opinion. "The question whether the sponges digest with the Ectoderm or with the Entoderm cannot yet be decided. But it does not appear improbable that both layers (Polaejeff, l. c.) may have that function. The Keimblätter of other Coelenterata are nearly analogous, so that we can conclude that the layers of the much less highly organized Sponges are still more so, and that we have in the Sponges *different germinal layers before us*." (Proc. Linn. Soc. N. S. Wales, vol. 9, pt. 2, p. 438.) The opinion of those of us who held that the tissues of sponges were more primitive than in other types of Metazoa was founded largely upon the observations of the structure of adults and their general morphology. It is, therefore, very satisfactory when such a profound student of embryology and histology as Metschnikoff is found to be advocating a similar opinion after minute, thorough, and extended investigation of the embryology and histology of the same forms. In speaking of the general relations of sponges to Coelenterata (Zeitschr. Wissen. Zool., 1879, p. 379) this author writes: "Es kann aber nicht bezweifelt werden, dass trotz aller Analogien, die Spongien einen viel niederen Zweig der Metazoa als ihre nächsten Verwandten, die echten Coelenteraten, repräsentiren;" and farther (p. 377), in describing the relations of the tissues he adds: "dass bei den Schwämmen diese Schichten (ectoderm, mesoderm and endoderm) noch nicht den Grad der Selbständigkeit und Unabhängigkeit erlangt haben, welcher bei den höher stehenden Thieren so characteristisch ist." It is not at all adverse to this opinion that intracellular digestion should take place locally in the higher forms of Metazoa. On the contrary it would be very surprising if the cells of the tissues should retain the forms and structures of Protozoa without exhibiting similarity of functions.[1]

The essay of Mr. Saville Kent (Embryol. Sponges, Ann. Mag.

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[1] We know from the researches of Metschnikoff (Zool. Anzeig., 1878 and 1880) that intracellular digestion takes place in the Planarians, Hydroids, and Medusae. Parker, (Proc. Roy. Soc., 1880) has also witnessed the same phenomena in the digestive cavity of Hydra, and Lankester (Jour. Micr. Sci., 1881) in the curious Medusa, Limnocodium.

Nat. Hist., ser.2, vol. II) is an able discussion of the Protozoonal characteristics of the Porifera. His efforts to show that these affinities are sufficient to justify the association of Porifera and Choanoflagellata, are, however, founded upon conceptions of the structure of the former which do not seem to us to be admissible. Mr. Kent has not detected the chorion, and in consequence has supposed Carter, the discoverer of this structure, to have been in error when he asserted that the segmentation of the sponge ovum always takes place inside of such a special envelope. This fact as has been stated above is unquestionable, and one of Mr. Kent's strongest points, that the poriferan ovum is not a true egg, falls to the ground.

Another of Kent's views is that the ampullae are developed from ova-like bodies in the mesoderm, and are mere aggregates of Protozoa; but the series, which he figures as proof, is open to serious criticisms. The author must have confused the early stages of an ovum (pl. 7, f. 1–4) with a fully matured spermatocyst (pl. 7, f. 5), and a no less mature stage of the same body (f. 6), A spermatocyst (f. 5–6) with its included zoons is thus presented as one of the younger stages of the ampullaceous sac (f. 7). The chorion appears in Mr. Kent's figures 2–3 of this series, is not present in figures 4–6, and is of course absent in his ampulla (f. 9) which forms part of the same series of figures.[1] Thus Mr. Kent mixed up ova, spermatocoysts, and ampullae in his observations, and he was, therefore, unable to distinguish true ova among sponges, and has been led to make an erroneus estimate of the affinities of the Porifera and choanoflagellate Protozoa. Nevertheless many of Mr. Kent's comparisons, appear to us to prove a much closer relationship between the Protozoa and Metazoa than has been heretofore admitted by the opponents of this view.

An undoubted Protozoon, Proterospongia Haekelii (Man. Inf., vol. I, pl. XII, p. 365) is described by the author as "a stock form from which all the sponges were primarily derived." This colony of flagellate and collared cells buried in a structureless jelly does not essentially differ from the single layered colonies of the

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Dr. Wilson (Mittheill. aus. d. Zool. Stat. Neapol, vol. 5, pt. 1) observed similar phenomena in the mesenterial filaments of the Alcyonaria. Metschnikoff also has made us familiar with other examples of a similar sort in his interesting article translated in Quart. Journ. Micr. Sci., Jan., 1884.

[1] A part of these same figures is given in the Manual of the Infusoria, pl. 9.

Phalansterium and Spongomonas (pl. 12), except in being a round mass. Carchesium and Zoothamnium (pl. XII), which though Ciliata are similarly buried in a structureless blastema or a "Zoocyntium," show that the zoocyntium is a homoplastic structure which cannot be considered as an indication of close affinity between the flagellate cells of Protozoa and those of the Porifera. It is also an acknowledged product of the collared cells and not a cellular mesoderm or its homologue.

The figure of Desmarella moniliforme (pl. 11, f. 30), a free floating colony of eight zoons with collars and flagella, is very similar to Clarke's figure of an isolated fragment of the endoderm of Ascaltis, and seems to us more nearly allied to a sponge than any other Kent has figured, since this has no zoocynctium and the zoons lying side by side have more nearly the relation and aspect of a true membrane.

Flagellate colonies like Proterospongia may be considered as remotely foreshadowing the ciliated larva of a sponge; and possibly the blastema or zoocyntium may be the homologue of the structureless jelly which filled the blastocoel, and in this sense their characteristics seem to argue strongly for the derivation of the Porifera from the Choanoflagellata as the stock forms of Metazoa. The figure of Desmarella appears to us to have a similar meaning as regards Bütschli's placula and strengthens the theory of the derivation of the essential characteristics of the monoplaculate embryo of the Calcispongiae from similar flat colonies of single layered Protozoons. The Monoplacula may have been a synamoeba, and the Desmarella merely a homoplastic colony, but it shows that collared cells may arise in a colonial form, which is similar to that of a true membrane and in which the cells adhere without the aid of a zoocyntium or enclosing blastema.

Huxley was the first author, who realized the great differences between the Porifera and the remainder of the Metazoa. He designated them (Quart. Journ. Micr. Sci., 1875) as Metazoa Polystomata in contrast with the Metazoa Monostomata, which included all the remaining Metazoa. Though we have on several occasions criticised this view, we are now glad to be able to retract, and even to reinforce Huxley's opinion with the theory of the peripheral growth of vases and oscula in sponges. Ectodermal invaginations are shown in the process of formation, in this group, and we can homologize them with stomodeal, proctodeal and possibly other invaginations occurring in the embryos of higher animals which are also traceable to a tubular origin. These homologies show that the cloaca of sponges are true oscula, though they must be estimated as primitive oscula. The stomodea of many higher animals are, however, not primitive oscula. That is to say they do not connect with the primitive archenteron as do the oscula of Porifera, but arise for example in Vertebrata, as secondary invaginations connecting with the mesenteron.

McAllister in his "Animal Morphology" first correctly designated the sponges as a distinct branch equivalent to Coelenterata under the name of Poriferata. This view was supported by the author (Proc. Bost. Soc. Nat. Hist., vol. 19, 1878 ; and in Johnson's Encyclopedia, Appendix, p. 1668) from an independent standpoint, and before having seen McAllister's statement. Polaejeff, in his Calcispongiae of the Challenger, lately advanced a similar, but more reserved opinion, apparently without having read either of these views.

These observations and conlusions in so far as the sponges are concerned can be summarized as follows:

The Porifera are peculiar in the plasticity of their forms, presenting great variation within the same species, and tendency to coalescence; in the possession of an inclosed skeleton formed by the ectoderm; in the universal presence and essential necessity of pores, and the peculiarities of the external aspect arising from the presence of these structures, and in the absence of any marks of bilateral distribution of the parts. The interior of primitive forms has a unique character due to the protozoonal forms of cells in the endoderm of the lowest type throughout life, and to the pores perforating the wall; while the interior of higher forms has a still more marked appearance due to the vast number and irregular radiatory and often branching arrangement of the coelomic sacs or ampullae and their primitive shapes; the presence of two systems of gastro-vascular tubes; the epithelium of the archenteron, and the protozoonal forms of the cells of the ampullae. The habitat is universally sedentary, and complicated colonial associations of spongozoons are unknown. The sieve-like organization and mode of growth of the coelomic sacs, and middle layer, and the comparative uniformity of the habitat have all contributed to the suppression of the formation of complete buds. Thus the direct growth of the individual has built up spongozoons which may be called massive or branching individuals, but are in no sense colonies, except in the forms with a thin mesoderm, Ascones. The characteristics of the middle layer are so exceedingly primitive that we have called it mesenchyme. It is the seat of the reproductive, as well as assimilative cells in all except the lowest forms, Ascones, thus presenting a strong contrast with the mesoblastic and mesodermic tissues of higher forms.

The peculiarities of the type are still more marked in the young. The earliest stage, as in all Metazoa, is amoeboidal, but in the next stage the monoplaculate form of embryo is prevalent, as might have been anticipated, in the Calcispongiae as the most generalized structures among the Metazoa. The more concentrated forms of the ovum, the morula, amphimorula, parenchymula and gastrula, are not peculiar to the Porifera; but in the later stages the Cinctoplanula appears, and at once enables the observer to distinguish any form in which it is present as a sponge, and this is followed by the equally characteristic ascula and ampullinula. There are unquestionably type-larval stages in most of the branches of the animal kingdom, and time and fuller knowledge will probably bring embryology and adult structures into agreement with each other.

Not only can we distinguish a sponge by the Cinctoplanula, Ascula and Ampullinula, and the Hydrozoa by means of the Hydroplanula and Actinula, and the Actinozoa by the formation of the fleshy septa and characteristics of the Gulinula, but it has been long recognized that this was practicable in the last two branches, as well as among Crustacea in which the Nauplius is prevalent, among Mollusca in which the Veliger is typical, among Echinodermata in which the Pluteus prevails, and among Vertebrata in which the test of affinity is the notochordal stage. In all of these branches, except the last, there are groups in which the typical embryonic or larval stage is absent, and in some certainly this absence can be accounted for as due to the law of concentration. The suppression of the Cinctoplanula in Sycandra, the absence of the nauplius in the Astacidae, and of the Veliger in the Cephalopoda are all examples of highly specialized type which concentrate or suppress the characteristics of the type-larval stage in their development. The absence of the type-larval stage in an animal is not, therefore, evidence against its association with a branch to which its structure brings it in undeniable affinity, provided the omission can be explained upon the basis of concentration and specialization ; but on the other hand the presence of this stage is absolutely determinative.

The term Radiata established by Cuvier has been banished from the literature of Zoology under the impression that the general homologies which might be made between the types of Porifera, Hydrozoa, Actinozoa and Echinodermata would have no taxonomic value. While recognizing that the distinctions which have been shown between these types are sufficient to entitle them to the rank of different branches, we have never felt disposed to slight the homologies founded upon the prevalence of the tendency to vertical division of the body and the predominantly radiatory symmetry in the arrangement of parts. This appears now to receive additional confirmation since the radiate symmetry evidently correlates with similarities in the modes of growth of the diverticula of the archenteron as was shown by Alexander Agassiz (Embryol. Starfish Agass. Contrib., vol. v, p. 65) before the views of the Hertwigs with regard to the coelom enabled him to use the general homologies of the body cavity in support of these views. The Hydrozoa, Actinozoa and Echinodermata are the higher terms of this grand series of animal types, and to this list we add the Porifera as the first and lowest term, thinking that we are amply justified by the facts adduced above in estimating them as true Metazoa radiata.

We can now, therefore, proceed with a certain confidence to point out still more definitely the primitive character of the structures of Porifera. These animals with their thick middle layer filling up the space between the diverticula, and with these cavities in direct connection with the exterior by means of tubes, present us with a structure, which in horizontal section would not be very remote from Prof. Sedgwick's ideal diagram of the supposed ancestral type of the segmented animals (op. cit., pl. 3, f. 7). If we imagine this figure altered so as to obliterate the peripheral tube connecting the coelomatic cavities, it would become an approximate diagram of a horizontal section through an adult sycon or the ampullinula stage among Carneospongiae.

The figure, however, would be round instead of elliptical and there would be no nervous ring above and around the actinostome (stomodeum), which would also be circular. We should also go a step farther and trace under this diagram another in which an embryo in similar section would appear without an actinostome. The mouth would be presented as an open, enlarged blastopore leading into a ciliated cavity, the walls of which would be porous and presented as triple, but with extremely thin mesenchyme, and the cells of the ciliated endodermic and smooth ectodermic cells almost in contact on the severed parts, and actually in contact in each pore. This diagram would correspond with an ideal horizontal section through an ascon if supposed to have the mouth and blastopore coincident, and if deprived of the skeletal spicules, or to a similar ideal section through a larval sycon in the ascon stage of development when without spicules. This ideal form would be essentially a gastrula perforated with pores, but consisting of three layers and not of two layers as imagined by Haeckel, Huxley and Sedgwick.

Thus although obliged to differ in important details from these authors our results are approximately similar. In other words the gastrula theory appears to be supported by both the observed gradations of structure and those of embryology among the Porifera; and the adult ascon, the lowest Metazoan, is a triploblastic gastrula differing only from the ideal gastrula in being perforated with pores.

Recapitulation and Remarks.

The tissues of Metazoa are, as is now generally recognized, built up by the parthenogenetic fission of cells; and it is evident that the massiveness of tissue is due to the extremely rapid growth of cells by this mode. They form membranes or masses united in forms similar to Desmarella, and not in forms similar to those colonies of Protozoa which are bound together by means of plasma or by stalks. In so far as this morphological result is concerned, therefore, the cells of the tissues are completely divided, and represent only the most exceptional structural results of agamic fission when compared with the formation of colonies among Protozoa.

The simplest free zoons of the Amoebinae may break by complete agamic fission into many zoons, but this is evidently a primitive unencysted condition introductory to the association in simple colonies, which characterizes the adults of most of the Protozoa, and to the more concentrated mode of reproduction by complete fission within a cyst, which follows this stage in the complicated cycles of transformation among the higher forms. The Protozoon has normally three periods in its life, the youngest individualized zoon, the intermediate or adult, during which it forms simple colonies, and the final reproductive encysted form, which is an individualized zoon again. Ova and spermatocysts or their homologues accompany the cysts in the higher Protozoa, and are the direct descendants of the reproductive or encysted zoons. They are the third products of the ontological cycle, and through them all the influences of heredity are conveyed. By this perpetual reduction of the cycle in every individual, and the continuous acquirement and transmission of new characteristics, more and more complicated colonies appeared; and finally the three-layered Metazoa were established. These have also the three periods of life in homologous cells and in similar order, the individualized zoons or cell of the ovum, the complex colony which is built up by its growth and fission, and the production finally of reproductive and encysted zoons or cells through which the influences of heredity are transmitted. These transformations, however, occur in a very concentrated fashion, and the reproductive zoon must be considered as belonging to the young and adult period of the complex colony instead of the degradational or senile as in Protozoa.[1]

No connected colonies of zoons or cells are built up in the Metazoa, representing the incompletely divided colonies of the adults of Protozoa, except in incomplete segmentation of the ovum. These forms are skipped and the complex colonies, which arise by fission, consist of zoons completely divided from each other. The cycle of transformations is not only shortened by this omission, but the origin of the reproductive bodies is carried back into the adult stages and earlier in many forms, and the rapidity of the processes of complete fission due to concentration produces masses of tissue and membranes in place of loosely connected colonies as among Protozoa.

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[1] We have formerly pointed out (Memoirs Bost. Soc. Nat. Hist., 1866, vol. 1; and Proc. Amer. Assoc. Adv. Sci., vol. xxxii, p. 354) that there was a constant tendency among fossil Cephalopoda in the highest and most specialized forms (those which necessarily possessed the most concentrated development) to inherit senile characteristics of progressive and earlier geological forms so that they appeared sometimes even in larval periods. This law is of great interest since it enables us to correllate the transformations of the senile individual with the degradational changes taking place in the highest and often most specialized forms occurring in the paracme of groups, and to show that degradational transformations are similar in their results whether occurring in the individual, or in the species, or in larger groups of the same class or branch.

We have not considered the structure of the cells as worked out by various modern investigators, because we do not believe the reticulum (Frommann) and the possible connections of protoplasm binding cells together into masses (Heitzmann) could sensibly shake this result drawn from the general morphology. The many disconnected, wandering cells with their independent organization and functions favor this conclusion; and the sight of these and of ova in the mesenchyme of sponges, and the evidence of their functions here and elsewhere in the animal kingdom are sufficient to bring a candid mind to open confession of the existence of exact parallelism between them and the single, individualized Amoeba.

These and other morphological facts have led, so far as we know, only to comparisons between the ordinary tissue cells and the adults of the amoebae, and it has been assumed that these cells are the equivalents of the adult amoebae. Morphologically this seems to be true, but it does not account for the physiological differences between the Protozoon and the cell. The ontology of the cell, its production of tissue, and the reduction of the cycle of transformations cannot be explained, unless we attribute to it a concentrated energy in reproduction and a tendency to form complex associations much greater than that of the Protozoon.

Morphological comparisons show that the succession of events was first growth, then fission, then the union or concrescence of the divided zoons and an exchange of their complementary parts; evidently all of these influences bear upon the tissue cell and influences its reproduction. Nevertheless two cells do not combine previous to reproduction by fission, and whatever the effect of the original impregnation may be, we are obliged, therefore, to regard a young cell as a modified agamic larva-like form or zoon, when compared with the full grown Amoeba. If descent from Amoebae, through Flagellata and Ciliata is assumed, then the task of proving young cells to be immature forms becomes easier. In this case they are obviously forms, which, like the ova of many Metazoa, have retained their ancient, amoeboidal characteristics while losing their later acquired flagellate and ciliate similarities. We cannot use the words embryo and larva, which belong to the ovum after impregnation, and we, therefore, propose to designate the cell an autotemnon,[1] in contrast with the embryo which is more specialized. The least specialized tissue cells of the mesenchyme differ least from the individualized agamic zoons of the Protozoa; while the spermatocysts, as more highly specialized, encysted male zoons, retain the cycle of agamic transformations derived from their male Protozoonal prototypes, and are intermediate to the encysted female zoon or ovum. The spermatocyst, in other words, is not dependent upon impregnation for its development and has necessarily retained more of the characteristic, successive transformations of the primitive agamic form than the ovum. This last has become dependent upon impregnation. The tendency to earlier and earlier impregnation in successive generations, and the correllative concentration of useless autotemnic stages has finally established the ovum as a more highly specialized form of cell.

The conditions under which fission occurs in the cyst, and in the ovum and spermatocyst are similar as long as the zoons or cells are all similarly confined, but when they burst the envelope and become free, the surrounding conditions differ and they correspondingly diverge.

The early encystment of the ovum, the non-production of the colonial form by incomplete fission, the dependence of the feminonucleus upon impregnation, and the great rapidity and extensive character of the changes by which the diploblastic parenchymula and triploblastic gastrula are built up, all show the excessive concentration of development which has taken place, when any blastula is compared with the corresponding forms among the Volvocinae. There is also a distinction between the mode of development of the Volvocinae, and the lower Protozoa, which has, we think, great significance.[1] They have a prolonged gestation which can be compared with the similar prolongation of this period in the development of the ovum in the Metazoa. The reproductive bodies of all kinds, whether asexual or sexual, are retained within the body for a comparatively prolonged period, during which they undergo division and attain very nearly the adult structures and aspect, according to Bütschli, and acquire cilia before they become free. They, in fact, attain the age at which they compare quite closely with the locomotive embryos of Porifera and many other types of the Invertebrata before they become free.

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[1] From αὐτὸς, self, and τέμνω, to divide.

The whole process of segmentation takes place under conditions which effectually protect the earlier stages just as it does in the Porifera and in the higher Metazoa. The action of protection as correlative with concentration, and the consequent suppression of the more indirect modes of development of the ancestral types, and the subsequent influence of protection in helping heredity to maintain uniformity in the embryo of the type, have been discussed by the author in "Genesis of Planorbis at Steinheim," and also in "Fossil Cephalopods of Mus. Comp. Zool." (Proc. Am. Ass. Adv. Sci., vol. XXXII, p. 232.

Balfour also subsequently advocated the same idea, but attributed concentration, or, as he called it, abbreviation, to the action of protection, whereas we regard the two things as correllative, since protection often does not exist when concentration takes place. It needs only be said here that protection of the embryo often appears to arise simultaneously with concentration, and to occur through some change of habit or habitat. Such changes are in our view reactions of the organism, due to its efforts to meet the requirements of changed or new surroundings by modifications of its acquired structures and organs partly according to Dohrn's hypothesis, and partly according to Ryder's theory of mechanical evolution, and we must also recognize the influence of effort as an essential cause of modification, as suggested in Cope's theory.

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[1] We cannot see why their sexual reproductive bodies cannot be designated as ova and spermatocysts. They are ova and spermatocysts in characteristics and structure, and must be considered as essentially the same. Volvox itself is, therefore, in reality a true egg-bearing animal with only one layer to the body, and must, therefore, be considered a true Protozoan; but it differs only from an embryo sponge in respeot to the number of layers in the body, and the ordinarily accepted difference between Metazoa and Protozoa breaks down in the effort to find the differences between its sexual zoons and those of the Porifera.

Effort, either as a purely mechanical reaction in response to irritation or excitation, or in less primitive shape, is probably one of the causes of all structural modifications, the more remote or ultimate cause being the direct action of the environment producing the primary irritation or excitation. The older naturalists respect the Lamarckian theory of effort when applied to man, and designate all attempts to apply it to the lower animals as speculative, whereas it is not more so in their case than in the history of progress in man himself. Intelligent effort has no definite boundary by which it can be separated from automatic effort, or the exercise of any of the organs or functional powers on the part of man, or the lower animals, and they all have their birth in purely mechanical reactions which have been demonstrated by many authors, notably Semper, Dohrn, Cope and Ryder.

There is a gradation in the stages of development of the ectoderm, endoderm and mesenchym in the sponges which shows them to have retained the ancestral protozoonal characteristics in some cell-zoons more than in others. Thus the ectodermic cells in all the Porifera become permanently transformed into flat epithelial cells losing their feeding organs, the collars and flagella, whereas the cells of the endoderm in some forms, such as the Ascones probably, never lose these organs at all, and in others lose them only transiently at certain stages, or only locally on the walls of the archenteron in the intervals between the diverticula or ampullae.

In the mesenchyme the cells have been subjected to fewer changes and they preserve their ancient amoeboidal forms comparatively unaltered. The great change in the evolution of the group probably took place after the transfer of the principal seat of assimilation from the endoderm to the mesenchyme. This transfer occurred in the genesis of some Sycones, and other higher forms. Then the mesenchyme probably began to become thicker and to show more definite tissues, as in the dermal layers in many forms, such as Spongilla and Spongia, Apysilla, etc., but whether this differentiation ever goes to the extent of producing specialized contractile muscle cells having a fixed form is doubtful. The localization of reproductive zoons in this layer may be a secondary result of adaptation, or may have a primitive and hereditary meaning, but of this there seems at present no solution. Their presence, however, gives to this layer an apparent complexity, which is puzzling until one notices that the mesenchyme contains elements, which in higher animals are more completely localized in other layers and in distinct organs. This polymorphism of the cells is really a generalized characteristic which is in strong contrast with the highly specialized uniformity of the flat epithelium of the ectoderm, and the intermediate condition of the endoderm in the Sycones, Leucones and Carneospongiae, as shown by the flat epithelium of the archenteron, and the collar cells of the ampullae.[1]

The spermatocyst in the mesenchyme of Porifera is like a single wandering cell or any other cell of the tissues, an autotemnon, but it becomes confined in an envelope within which it undergoes spontaneous fission, and the zoons produced possess sufficient resemblance to true monads to have justified Oken and other authors, in considering them as actually monads.[2] They are, however, morphologically, forms of secondary origin, which have these characteristics developed at an early stage of growth. Their ordinary form and structureless body remind one very forcibly of the simple form of cell as figured by Frommann, in his Struct. etc., Zellen, pl. 1, fig. 1, and their development and subsequent history prove that they are nuclear in origin and affinity.

Whether they do or do not take food seems to us to have no bearing upon the facts of morphology, and to be a question of adaptation to surroundings. The essential difference between them and flagellate Protozoa is, that they, though structurally young forms when compared with the more highly organized adults of the Flagellata, or even with the cell from which they originated, have already acquired the habits of full grown males or microgonids among

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[1] According to Roux "Kampf der Theile im Organismus" this would be the result of natural selection acting upon the cells: this may be true in part, but the origin of the epithelial form may be due to pressure, the origin of the ampullaceous form also to pressure and excess of growth, the origin of the collar and cilia to heredity purely, its preservation to continuance of similar conditions and natural selection be only a secondary influence.

[2] In this connection it is very interesting to read the comparisons of Nussbaum (Archiv. Mikr. Anat., Vol. XVIII, p. 1) and their conformation by A. Swaen and H. Masquelin (Archiv. de Biologie, Vol. IV, p. 797) upon the structure of the testicular and ovarian envelopes and the development of the spermatocysts and ova.

Protozoa, and are ready to seek out and fertilize the female zoon, which in Metazoa is of course the ovum.[1] Their habits, therefore, sufficiently explain this retention of the agamic, flagellated, primitive form.

When we consider the whole series of transformations of the ovum it becomes apparent, that it is an autotemnon having the amoeba stage well and clearly developed. The ovum develops parallel with the spermatocyst up to the period of division of the nucleus into two parts, the masculonucleus and the feminonucleus. We have tried, in common with other authors, to show, that the masculonucleus of the ovum is probably thrown off in the polar globules during the stage of agamic division of the nucleus and that this process which is the homologue of that by which the masculonuclei are excluded from the spermatocyst after having been transformed into spermatozoa.[2]

M. O. S. Jensen has combated this theory (Archiv. de Biologie, Vol. IV, p. 68) on the ground that there is no structural distinction (visible?) between the central cells which are useless and the peripheral cells which bear the spermatozoa, that they differ only in position and that it is more reasonable to suppose that the cells becoming earlier developed would necessarily assume a peripheral arrangement, and not only prevent by their excess of development the growth, but even occasion the degeneration, of the internal cells. This might be in a certain sense perfectly acceptable as an explanation of the way in which the peripheral mode of growth arose, but it is difficult to explain the evident eagerness of the spermatozoa to enter the eggs, or the tendency of the spermonucleus to unite with the feminonucleus of the ovum upon any supposition which does not assume heredity as its basis.

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[1] It is here interesting perhaps to note, that this conclusion was formulated before we became acquainted with Butschli's or Carter's researches (Amer. Nat., Vol. XVIII, p. 460, 1884).

[2] We greatly regret the inexcusable carelessness of having omitted to notice the remarkable writings of Prof. Ed. Van Beneden on the bisexual nature of the nucleus. These are the only embryological writings which produce the proofs of this hypothesis in illustrated form, but we were not aware of their existence until too late for notice. Prof. Ed. Van Beneden (Fecond. Maturat. de l'oeuf. Archiv. de Biol. Tome VI, 1883) advances precisely similar views to those of Dr. Minot, and shows the phenomena of fecundation and the double composition of the masculonucleus in a series of remarkably clear illustrations. The author claims to be the discoverer of the bisexual composition of the nucleus of the ovum and refers to his paper of Dec., 1875 (Bull. Acad. de Belg., Ser. 2, Vol. XL, 1875) as containing the first statement of his discovery. Though not pretending to forestall the judgment of those better qualified to decide the merits of these claims, we find that Prof. Van Beneden was probably the first to announce the basal facts of the bisexual theory, but that he did not give all of the essential conditions of the phenomena of conjugation between the male and female parts of the nuclei in his first paper. This author in the work just cited (p. 700) suggests, that the peripheral pronucleus is probably partially formed of spermatic substance, that the central pronucleus is female and that the segmentation nucleus is a compound body resulting from the union of these two nuclei, and is, therefore, probably bisexual. This statement includes all the basal facts of the genoblastic theory, with, however, two important exceptions. It omits any notice of complementary behavior or functions of the useless parts of nuclei in both the spermatocyst and ovum. This essential condition of the conjugation of the nuclei does not seem to have been elaborated by Van Beneden until 1883, long after the appearance of Dr. Minot's paper. I have also to apologize for having overlooked the fact that Dr. Minot (Proc. Bost. Soc. Nat. Hist., Vol. XIX, p. 170) had already proposed to name the original bisexual nucleus "genoblast," the female part, "arsenoblast," and the male, "thelyblast," and these terms have precedence of those we have advanced above, or of those proposed by Van Beneden.

If this be true, the appearance of this process in the ovum during the agamic stage exhibits an earlier inheritance of a characteristic which in the Protozoa occurs only after and as a result of impregnation, except in some of the more specialized Flagellata and Ciliata, where the existence of spermatocysts and spermatozooids leads one to anticipate a corresponding differentiation in the female zoon, which appears to be in reality an ovum, and to develop, like an ovum, into a blastula, as pointed out by Butschli.

The vitelline membrane seems to have been considered as a difficulty in the way of homologizing the ovum and the body of an encysted Protozoon. Dr. Minot, in a paper as yet unpublished, has homologized the wall of a cyst, and the zona pellucida of the ovum with each other (Science, Vol. IV, 1884, p. 339). We feel naturally doubtful whether this comparison can be proven, but we do not, on the other hand, consider it at all necessary, that such close comparisons should be made between purely adaptive parts like the protective coverings of the ovum and the structureless cyst wall of the Protozoon. The cellular membranes of the pouches in which the ova and spermatocysts are isolated and developed in the Porifera are very instructive in this connection. The ovum and spermatocyst must make room for themselves, and provide at the same time necessary food for their early growth and it is well known that these reproductive bodies are predacious cells which doubtless grow at the expense of the neighboring cells. They can, therefore, be regarded as having a decidedly irritating action upon the adjoining tissues. This process of continued irritation would be sufficient to cause the flow of wandering cells to and around the ova, and, thus as in the case of internal burrowing parasites, bring about the formation of more or less thick walled cysts. These in time would tend to stiffen and lessen the supply of food, and thus limit the size of the spermatocysts and ova. There are marks of this differentiation in the sponges, some of which have cysts with thick walls composed of several layers of cells as in Aplysilla sulphurea (Von Lendenfeld, Zeit. Wissen. Zool., Vol. XXXVIII, p. 262), while the thin walled cysts prevail in others, and probably in all the cysts become single layered and build a more or less stiffened chorion in later stages. Those with thick walls show the transition from the unprotected ovum as it occurred in the higher Protozoa, or possibly even in some sponges, to the inclosed ovum of the higher Metazoa or higher Porifera. The chorion, in other words, is a covering which arises at first as a protection of the tissue against the ova and spermatocysts, and then, acquiring through heredity fixed and inheritable characteristics and thin walls of differentiated cells, becomes finally a highly specialized single layer of epithelium.

With regard to the meaning of the early stages of the ovum, we come nearer to Bütschli (Morph. Jahrb., 1884), than any other author, and regard his placula theory as opening a way far more promising than any so far proposed. This author, however, voluntarily rejected the aid of the sponges in his arguments, under the erroneous impression that they were Protozoa. The embryo of the Calcispongiae is, however, as we have tried to show above, a single layered placula or a monoplacula, and is, therefore, directly comparable with the undifferentiated flat colonies of Protozoa which were more primitive than the blastula form and represent the simplest condition of a colony of Protozoa, like Desmarella of Saville Kent. They are, however, devoid of cilia at this stage and therefore more nearly perhaps represent a mass of amoeboid forms. The formation of the apical or esoteric cells from the cells of the monoplacula transforms this stage into a diploplacula, the older or basal cells becoming our exoteric cells. The approximation of the later stage in which true ectoblastic and endoblastic cells first appear to the more primitive and earlier stages in which the exoteric and esoteric cells of the diploplacula are formed can be explained by concentration of development and would necessarily end in the fusion of these two stages, and the ultimate production of a rounded globular and more or less solid form in which it would be difficult to distinguish the exoteric and esoteric cells, or in which this stage of differentiation might be entirely skipped in accordance with the law of concentration in development. The rounded globular forms of the morula would then replace the placula earlier in the life of the embryo and occasion its disappearance in more highly specialized forms, as in the Carneospongiae.

This theory is very similar to that of Butschli,[1] so far as relates to the origin of the placula, but differs in making the morula an important stage of the evolution of forms. Butschli points out the resemblances of the embryo of Cucullanus, Rhabdomena, and Lumbricus to the placula, and the apparently primitive mode of forming the segmentation cavity in the latter by the separation of the two layers is also given in detail by him. Butschli also considers the Trichoplax adhaerens of Schultze, as a living illustration of a full grown, primitive, placulate form.

We think also, that one ought to find primitive stages in the embryos of a primitive type, and this is eminently the case with Porifera. We should anticipate the opposite with a higher type like the worms, or any metameric animal, and this appears to be borne out by what Butschli brings forward in support of his theory.

In Cucullanus the earliest stages are rounded, and we cannot agree with Butschli, that the flattened form which follows this is a primitive placula, or diploplacula. The primitive placula is a single layer, must precede the morula, and cannot succeed this stage. It will be seen by our remarks above that the esoteric and exoteric differentiations would have occurred normally before the morula stage in the placula of Cucullanus, or else in fusion with it and therefore the double layered placula of Butschli must be necessarily a flattened morula in which the two layers had already been fused. The relations of the planula stage in Cucullanus and Lumbricus to the gastrula also indicate, that it is simply a modification of the morula stage, and not comparable with the earlier premorula stages of the embryo. The formation of the gastrula in Cucullanus is a beautiful example of extra growth of the ectoblast, as has been pointed out by Balfour, and in this and in Lumbricus a true epibolic gastrula is built up by this process which is not more primitive than that which occurs in the Ctenophorae or Tubulariae. The gastrula in other words is formed according to a highly concentrated secondary mode of development, and not by primitive or simple processes. We should, therefore, even while adopting Butschli's theory, decline to accept his typical examples as true illustrations of the theory, and hold rigidly to the law of succession in the stages of the embryo for justification of this opinion.

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[1] We first became acquainted with Butschli's views from an article handed us by a friend just before the reading of this paper at the meeting of the American Association, and our ideas with regard to the primitive nature of the sponge placula had been formed and written sometime before this event.

The central cavity of the blastula stage, the so-called Protogaster of Haeckel, connects with the exterior by a blastulapore, the "Protostoma" of Haeckel, which is normally closed later in the growth, but remains open for long periods in some sponges, as may be observed in the figures of Sycandra raphanus and in the larva of silicious sponges, as in the embryos of Halichondria and Tethya described above. The assumption, that such a primitive cavity necessarily originated as a gastric cavity, seems improbable. The prototype of this cavity, the aula, must have first appeared as the central hollow in a moving colonial form of Protozoa, simply as a mechanical necessity of the habits and mode of growth, and might have been useful as a float, but was probably not a gastric cavity, but on the contrary similar in every way to the internal cavity of the Volvox-blastula. The additional advantage of the possession of such a hollow in enabling the cells to use two sides instead of one, and to perform the functions of respiration, ingestion and excretion more completely, is obvious. The growing of the cells of the ovum into a hollow sphere, the blastula with its blastulapore opening externally, is described by Butschli as essentially similar to the growth of the adult, floating, spherical colonies of Volvox and Eudorina from a single zoon by fission. This author (Bronn's Thierreichs, Protozoa, pl. 45) gives a series of figures illustrating the development of the asexual zoons of Volvox, which fully substantiate his conclusions and together with Carter's (cited above), show that the closest comparisons may be made between the early stages of the ovum and those of all forms of Volvox, which is an open blastula like that of some Porifera before it leaves the parent colony and becomes free.

A friend has been kind enough to criticise this conclusion, and has pointed out the fact, that this early differentiation of exoteric and esoteric cells may be translated as due to an early inheritance of a tendency to form an endoderm and ectoderm which might possibly have been derived from a type in which these membranes had been present. This objection can, we think, be met by two considerations. The Porifera are, if we are correct, the lowest type of Metazoa, and in them the succession of embryonic metamorphoses indicates, that a true endoderm cannot be considered as represented by any external cells occurring in the placulate or early stages of primitive types of ova. The succession in the embryo is first, formation by segmentation of a placula with cells all similar, then the differentiation of apical or esoteric, and basal or exoteric cells. These are followed by the rounded morula, and the hollow amphiblastula, and in both of these last the endoblast is formed; but, as shown by Schultze in Sycandra, this endoblast is of mixed derivation, not being confined to the products of the apical or esoteric cells alone but partly formed by division of the more primitive exoteric or basals also. There is evidently here a confusion of elements which can be explained, if we are dealing with cells representing a colony of Protozoa in which the exoteric cells gave rise to esoteric cells above, and continued to supply the esoteric layer with new recruits from their own ranks by peripheral growth. This fact is, however, at variance apparently with the view that the esoteric cells are in any sense descendants of true endodermic cells, since as simple endoblasts they alone should be the fathers of all the descendent endoblasts and endodermic cells, and not stand in need of reinforcements from the exoteric cells below. The esoteric cells of the amphimorula of Porifera have not descended from forms in which the endoderm was fully differentiated, but from forms in which this membrane was only in the first confused stages of formation. The fully differentiated esoteric cells of the amphimorula become invaginated in the gastrula and become the rudiments of an endoderm, or a true endoblast.

Our view is, therefore, that the esoteric cells should be considered as the forerunners, and not as the descendants of true endodermic cells. In those cases in which an endoderm occurs internally by delamination, like that of Geryonea, and of Eutima, the internal cells arising from the inner ends of the external cells must be considered as due to the fusion of the earlier stages, and should be regarded as true endodermic cells produced suddenly by concentration of development, the ovum having skipped the earliest stages and also the gastrula. In other words, the mere fact that these cells are permanently internal makes them for the first time truly endodermic, and such cells are truly endodermic because they have become internal through inheritance from some ancestral gastrula. That is, we claim that the old and established laws of homology apply not only to the organs and parts, but to the primitive layers of ova and to the cell-zoons. Thus cells and the primitive layers must occupy similar positions with relation to each other in the body of the embryo before they can be considered as strictly homologous, and, therefore, no external esoteric cells can be homologized with internal endodermic cells, or be considered as their descendants.

The closure of the blastulapore, which occurs in most forms, indicates very clearly, that the internal cavity or blastocoel was not a digestive sac in any sense. In order to account for the differentiation of the esoteric cells, we have imagined them as necessarily and by position feeding cells in the ancestors of the diploplaculate stage. In the free morula and closed blastula the same cells, or their more modified descendants, would tend to retain similar functions. The differentiation of the poles would occur in this blastula form according to the same law, as is observed in the higher animals, and the tendency already initiated of the zoons of one pole to become exclusively feeding zoons would be increased by more frequent contact with food, and by being constantly occupied in the act of ingestion. The dimorphism of the colony having been thus kept up and established by a continuance of similar habits, and the aula correlatively developed, we should have a free moving form with the cells at one pole feeding cells, and at the other probably more efficient as respiratory cells. These last need not be necessarily inefficient as feeding zoons, but might have remained quite capable of this office, as well, also, as that of developing flagella for moving the body, and in fact resembling in aspect and structure what we actually find in the amphiblastula of some sponges. We here claim for the exoteric or ectoblast cells, that their possession of collars and flagella implies the existence of powers of ingestion. We think the negative evidence, adduced by Metschnikoff and others, in regard to these cells in the embryos of sponges is entirely inadequate to prove anything but the fact that they have not seen them actually feeding, and does not weigh against the observed functions of the collars and flagella of the Flagellata, especially the positive and convincing proofs brought forward by Saville Kent.

This view is quite similar in its result to the opinion of Balfour (Comp. Embr. vol. I, p. 122) which was also founded upon the idea that the Porifera presented characteristics of a more primitive kind than was usual in the higher types of Metazoa. Balfour recognized a difficulty in the invagination of the ciliated cells in Sycones, and thought that the possession of cilia was an essential character implying respiratory and locomotive functions. Balfour perhaps laid too great stress upon the similarity of functions, and this led him to suppose that the three layers in sponges might possibly prove to be distinct from the three layers of other Metazoa (*ibid.* p. 123), whereas they are truly homologous.

A dimorphic colony, like the amphiblastula with the cells at one end becoming better fitted to take in food, could be transformed into a parenchymula by the migration of differentiated feeding cells into the interior and the parenchymula could as we have tried to show become a true gastrula. There are no living forms, so far as we know, with which the parenchymula can be compared, and its probable meaning has already been indicated by other writers, especially by Metschnikoff, namely, that it implies a radical form in which the mesenchyme has arisen as a primitive mass by delamination.

We have also claimed that the gastrula of the Porifera was of general and genetic significance. This possibly indicates the former existence of an amphiblastula-like ancestor in which the invagination of the esoteric layer arose from the pressure occassioned by the unequal growth of the hemispheres, as first suggested by Dr. Whitman. This theory is satisfactory, so far as pressure may be considered as assisting in the first introduction of the tendency to invagination, but as a purely mechanical theory it cannot fully explain the whole series of phenomena. The aid of concentration in heredity is essential in order to account for the early appearance of both embolic and epibolic gastrulae in the embryos, and for the skipping of these stages in cases of the formation of the endoderm directly by delamination. The inwandering of the esoteric or endoblast cells of the parenchymula might be reasonably assumed as in part due to pressure. This appears to be a primitive mode of forming the endoderm, as stated by Schmidt and Metschnikoff, and, therefore, we should have to consider pressure as simply a possible cause aiding the tendency to inwandering, as it appears in the habits of these cells of the parenchymula. It is probable that this tendency was derived from ancestors in which a primitive invagination appeared as a late characteristic of the development, due to excess of growth in peripheral parts, as suggested above in the stomodea of Porifera, and that the same conditions of growth and pressure would continue to be present in the similar parts in the young of descendent forms as long as the conditions and habits were sufficiently similar and did not interfere with hereditary tendencies. The fact that the esoteric hemisphere is an excessive peripheral outgrowth of the exoteric cells in the amphiblastula is in perfect accord with the successive stages in the development of pits, and minor invaginations of the ectoderm. These are universally in their primitive stages peripheral outgrowths of the outer membranes, which form simple hollows and then these cups become hereditary invaginations in the embryos of descendent forms. The formation of stomodea and other ectodermic invaginations can thus be accounted for as in every way parallel to formation of gastrulae, and due to similar causes.

The invagination of the endoblast in the ordinary form of the gastrula is immediately accompanied and caused, as stated above, by pressure arising from the excess of growth in ectoblastic cells. The pressure on the endoblast after invagination is shown by the forms of the cells, which become elongated along the middle part of the cup, as in the well known case of Amphioxus described by Kowalevsky, and many examples by other authors. The growth and excess of pressure are also evinced in the elongation of the planula and the tendency of the at first broad blastopore to close up to a narrow opening by growth of the ectoblast. The usually columnar aspect of the ectoblastic cells of the planula, their longest axes being radial, or at right angles to the direction of the pressure is also favorable to this theory. These cells may be attenuated in Porifera at this stage (Barrois, Epong. de la Manche) so as to assume an almost linear aspect under low powers of the microscope. The succession of the stages is first a peripheral outgrowth increasing continually the diameter of the amphimorula, then invagination, then peripheral growth of the ectoblast, followed by elongation of the planula and contraction or obliteration of the blastopore. Heredity in these cases seems to be subordinate to growth, but this we think is due to the necessarily identical action of these inseparable forces. Heredity and growth are also necessary in order to account for cases of epibolic gastrulae, as well as for the existence of the planula. The action of heredity in the planula is obvious, but in the transitional epibolic gastrula the obvious mechanical action of growth still interferes with the clear perception of the influence of heredity. The growth of the ectoblast cells is so rapid in the last named, that the endoblast cells become inclosed as in the Ctenophorae, and the gastrula is formed by a process much shorter than is usual in embryos of the embolic type. In a planula we can see very clearly, that some other force in addition to growth has been at work, and that, whether we adopt Lankester's hypothesis or some other, we are equally obliged to call in the aid of heredity in order to explain the hidden steps by which the embolic gastrula has been transformed into this concentrated form of development. Keller (Anat. und Entwickelung einiger Spong. d. Mittelmeers, Basel, 1876), has given the fullest illustrated account of what we, in common with Metschnikoff and Schultze, have called the transient gastrula of the Calcispongiae.[1] A recent perusal of this interesting paper has suggested, that there is probably no better field for the study of the effects of pressure upon cells, than in these cases of transient invagination. It is possible that the invagination stage may be traceable directly to excess of growth in the ciliated cells, and their subsequent invagination as outgrowths to the reversal of this process, and at any rate this field is a very promising one in this direction. We have also noted above, the probability that the medullary fold was primitively a stomodeal invagination due to extra growth, and we are able to quote in this connection an observation of Dr. Hatscheck's, which appears to bear out this supposition and also to sustain other conclusions cited above, with regard to the effects of growth in the primitive production of such organs, especially among the ancestors of the Vertebrata.

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[1] We entirely failed through an unlucky oversight, to quote this paper above, where it would have been more appropriate. This is especially regrettable, since Keller's observations on the possible entodermal origin of the primitive spicules, and the assertion that the transient gastrula occurs normally after and not before the larva has left the parent, and that the young larva in the early part of the ascula stage is without cloaca, are exceedingly interesting in connection with the questions we have discussed.

Dr. Hatscheck (Arb. Zool. Inst. Wien., vol. IV, 1881, p. 45–48) attributes the origin of the primitive segments and other changes of form in the embryo of Amphioxus to the growth and energy of cells. He explains the origin of the medullary plate by differentiations in the cells caused by the extra growth of the neighboring cells of the ectoderm, and attributes the rise of the ends and final inclosure of the neural canal to lateral outgrowths due to the same cause.

The general presence of the different forms of the gastrula, including the planula, indicates, as we have tried to show above, that Haeckel was right in supposing that these stages indicated common ancestors for the whole animal kingdom. To this we have also joined (page 87) the architroch of Lankester by imagining a very ancient origin for the circles of oral cilia, around the blastopore of the primitive gastrula-like ancestors of the Invertebrata.

The history of the structural transitions through which the layers of the body pass in their subsequent history sustains the view that the Porifera are the lowest type of Metazoa. The endoderm and ectoderm reach a highly differentiated stage and appear as flat epithelial membranes, but the middle layer remains a mesenchyme containing, as we have stated above, the reproductive bodies of both sexes. The appearance of spermatozoa and ova indifferently in the same animal shows, that entire separation of the sexes does not take place so far as now known, among Porifera. It is not yet established, that cross fertilization occurs in any form, though there are as yet no grounds for the positive assertion that it does not occur. The history of the early stages exhibits a larval form in which the interior is solid for a certain period and the mesenchyme plays a much more important role than in any other branch of the animal kingdom, as might be anticipated from the adult condition and importance of this layer in the morphology of the group.

We have also tried to show that the general morphology and development indicated the gradual evolution of series of forms from a type similar to Ascones but without a skeleton, which we have considered directly comparable, as stated by Haeckel, with the gastrula. During this evolution the mesenchyme became more and more important, and as a result of its thickening the habit of budding was more or less suppressed so that the higher types must be considered as individuals with highly plastic forms, liable to excessive outgrowths, but not as branching colonies. The archenteron also remains unchanged throughout life, or gives rise to simple diverticula, or in forms with thicker mesenchyme the diverticula themselves form branching tubes. The fact that no coelom or body cavity is formed, in spite of the opportunity offered by the increasing thickness of the mesenchyme is very significant. It is not yet established that the mesenchyme does receive some additions in course of its growth from the endoderm and ectoderm, but so far as the histology is now understood it is doubtful. In other words the Porifera are intermediate with regard to structural composition between primitive larval individuals, like the free larvæ of all colonial types, and the differentiated colonies which arise from such primitive individuals after they become attached, as in the Hydrozoa. They contain all the elements necessary for the formation of complicated colonies with complete zooids of all kinds, sexual and asexual, in all their varieties as displayed in Hydrozoa; but in consequence of the less differentiation of the mesenchyme their primitive individuality is maintained and the processes of budding take place internally and externally without perfect correlation. That is, the exterior has outgrowths and so has the archenteron, but these are not strictly coincident and produce true buds only in the forms with thin mesenchyme.

The evidence in favor of the opinion that the diverticula or ampullae are strictly homologous with the archenteric diverticula of all other animals is very strong. The young have no diverticula until the ampullinula is formed and this correlates with the absence of these organs in the adults of the lowest type, Ascones. These facts among sponges seem to be in accord with the history and development of the diverticula among Hydrozoa and Actinozoa.

This has led to the conclusion that in all three of these types the diverticula are homoplastic organs.

The considerations we have presented above have, therefore, a direct application to the results of the work done of late years by Semper, Dohrn and others in tracing the origin of the vertebrata to some worm-like type. The whole of this evidence hangs necessarily upon the probability that the somites of the embryo of Amphioxus imply descent from a segmented animal; whereas, if we are correct, exactly the opposite view may be considered as the more probable, and the very close comparisons made by Semper between what he considers homogenous organs and parts in Vertebrata and Vermes can only be considered as evidence of the production of homoplastic effects by means of similar modes of growth and to the similar habits of elongated and necessarily bilateral animals.

We also object to the theory that the Vertebrata may be considered as descended from a coelenterate ancestor because the actinostome probably arose independently and very late in the phylogenetic history of the Hydrozoa, and undoubtedly arose independently in the Porifera. A stomodeum as it appears in the ascula stage or in a sycon or ascon may be a single opening not due to invagination, merely an enlarged pore or outlet. The cloaca of the more specialized sponges is first an outgrowth of the peripheral parts which becomes inheritable and causes the appearance of the ectoderm as a lining layer extending to an indefinite depth into the interior. A stomodeum, also, does not exist in most of the Hydrozoa except in the primitive shape of an outgrowth, the hypostome, which is the homologue of the internal actinostome of the Actinozoa. These facts and the late stage at which it arises in the Actinozoa during the gulinula stage shows us that so far as the low types are concerned it is an independent and homoplastic organ in all three.

There are no exact comparisons between the embryos of Ascidia and Amphioxus and those of the invertebrates which seem to include any stages later than the planula. Those that have been traced between the mesoblastic somites indicate homoplastic organs, but they seem to have no phylogenetic meaning. The distinct modes of development of the anterior invaginations of the vertebrates show that they had a different origin from the anterior tube of the actinostome, and cannot be considered homogenous with that organ in the Coelenterata. The medullary invagination is at first a stomodeum arising as a funnel around the blastopore, and then spreads forwards in the shape of two folds, which subsequently form a tube, and it is probable that the notochordal tube, and the lateral differentiations of the archenteron may have had a similar homoplastic simplicity of structure. The development in Ascidia of the notochordal cells and muscle cells from the walls of the archenteron invite the suggestion, that no true diverticula exist in this type. That the lateral muscles might have arisen as entirely disconnected and more primitive structural elements than the coelomata is shown by Kowalevsky's work on Cassiopea already quoted (Soc. Friends of Nat. Hist., etc., Moscow, pl. 2, f. 10–13). In this Hydrozoon portions of the archenteric walls grow out and become directly converted into muscles, but no cœlom is formed. The notochord may have primitively originated as a tube, but connections with the hypophysis seems to be a necessary condition of this theory, and though this is highly probable, it is not proven[1].

The homoplastic origin of the notochord, when explained in this way agrees with the subsequent origin of segmentation in the vertebrae as suggested by Cope. These facts and agreements in theory render it highly probable, that the whole phenomena of segmentation as shown in the distribution of the muscles themselves, the appendages and internal organs, including even the primitive somites, may have arisen independently in the Vertebrata in response to the simple mechanical requirements of motion in elongated bodies. Herbert Spencer in a treatise much neglected by naturalists (Prin. Biol., Am. Ed., 1871, vol. II, p. 199), has clearly shown that the origin of the notochord and of segmentation of the vertebrae and muscles may be attributed to muscular strains, and our speculations, though entirely independent, cannot lay claim to any original merit.

Our results are similar to those of Haeckel in so far they distinctly point to the gastrula and planula as the last stages which have a general genetic meaning, and show that these indicate a stock form for the whole animal kingdom. The clear distinctions between the type-larval stages in different branches of the animal kingdom and the fact, that the type larval stages make their appearance invariably after the planula or gastrula, and never under any conditions break this natural succession gives strong support to this opinion. It is possibly premature to say that no one type can be held to have descended from any other, but the Porifera, Hydrozoa, Actinozoa and Vertebrata appear to us entirely independent of each other. It is also very suggestive that two such closely allied groups as the Actinozoa and Hydrozoa, can be considered as homoplastic types, and that many examples have been brought forward by the author and Prof. Cope, where smaller and more closely allied groups, orders, families and genera show the same phenomena and are plainly homoplastic with reference to the origin of important characteristics of structure. These results sustain the opinion that homogenous characteristics are frequently so similar to homologous, or simply homoplastic characteristics, that it is not safe to consider any characteristics occurring in distinct groups as homogenous until their phylogenesis has been traced or their comparative embryology is fully understood. The views here advocated are also important in their bearing upon the opinions of those who like Cuvier, Louis Agassiz, Gegenbauer and Packard have denied that there is any genetic connection between the parts of the body in Vertebrata and Invertebrata. We quote in this connection the following significant words from Dr. A. S. Packard's paper on the "Aspects of the body in Vertebrates and Arthropods" (Amer. Nat., 1884, p. 855) a subject upon which he is so eminently qualified to judge.

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[1] We desire in this connection to correct the erroneous impressions likely to arise from the note regarding antero-posterior symmetry on page 107. We by no means meant to be committed to an assertion that the antero-posterior correspondence of the segments could be considered as in any sense the same as the lateral correspondences.

"At all events the present problem is, as embryology shows, so remote in its bearings; the common point of origin of arthropod and vertebrate, the fork in the primitive developmental path where the two branches began to diverge, is set so far back in the animal scale, and is so remote in geological time, that with our present knowledge we are inclined to regard the consideration of such problems as belonging rather to metaphysics than to pure science; although it should be granted that farther researches among the lower worms may yet result in the discovery of facts bearing upon the origin or the singular differences in the disposition of the arthropod and vertebrate nervous systems."

The hypothesis of the common, but independent origin of types is also supported by all collateral evidences. The results of palaeontologic research have carried back the origin of distinct types farther and farther every year. It is now established, that there was an excessively sudden appearance of vast numbers of forms in the Cambrian or perhaps earlier as claimed by Professor Marcou.

We have applied this specific statement as a generalization to the history of smaller groups of fossils in several branches of the animal kingdom, and in many formations, and have found that the sudden appearance of the smaller groups occurs according to the same law.

There is an obvious plasticity in the animals which first make their appearance in any unoccupied field, or at the beginning of any new formation, which reminds one of the plastic nature, of the most generalized type of Metazoa, the existing Porifera. The generalized types, which always occur first in time, exhibit exceptional capacity for adaptation to the most varied requirements of the surroundings, and meet the conditions of the new period or habitat by the rapid development of numbers of suitable and more highly specialized forms, species and genera.

The whole picture as presented by morphology, embryology and palaeontology favors the hypothesis we have previously advanced in papers cited above, namely, that the early geologic history of animal life, like the early stages of development in the embryo was a more highly concentrated and accelerated process in evolution, than that which occurred at any subsequent period of the earth's history.

The history of the Porifera and higher Protozoa suggests also that the evolution of the Metazoa may have occurred more rapidly than we can now calculate. One of the great errors of the present day is the assumption, that such changes and transitions occurred slowly and gradually; and it is evident, that this assumption is based almost wholly upon investigations of the more highly specialized animals, in which the capacity for change may be reasonably considered as very much less than in their more generalized and embryonic ancestral forms.

The history of every embryo is a progress from a more generalized to a more specialized form. We may make partial exceptions in favor of those forms in which the surroundings have been such as to destroy progressive characteristics, and have replaced them with retrogressive characteristics, but even these exceptions are the very best examples of a high specialization, as in the case of parasites, the Cirripedia, and hosts of other forms. All specialized forms which are strictly progressive, show a certain stability and uniformity of characteristics, a less noticeable tendency to variation, which is a result of their fitness for the narrower fields and habitats in which they exist. It is, therefore, illogical to argue from investigations upon them, that a corresponding uniformity existed in their ancestors.

The great mass of life, as shown by the fossils, has been progressive, and the progress was similar to that of the individual from a more generalized to more and more specialized conditions and structures. The primitive stocks like the primitive Metazoa, the Porifera, were certainly much more variable and unstable than the later and more complicated forms which are more stable and less susceptible of change. Thus when radical changes become necessary in order to sustain the life of the species of a group, they die out as did the Ammonites, or decay as did the Nautiloids, and exhibit most clearly the stability they have acquired as progressive forms in their inability to meet the requirements of different modern conditions.

This law of progress in structure is precisely parallel to Dr. M. E. Wadsworth's law of the evolution of chemical compounds on the earth's surface, and forms a supplement to his hypothesis of the progress of inorganic substances from unstable to more and more stable combinations, and his researches first suggested the idea we have given above.

In conclusion we desire as a personal matter to state, that as it proved impossible to illustrate this paper, the author, being about to enter upon a long series of researches of a very different nature from those given above, was obliged to take advantage of the present opportunity of publication, or resign altogether the idea of making his work in this direction useful outside of the class room.

Dr. M. E. Wadsworth read a paper on the evidence that the earth's interior is solid. (See Amer. Naturalist XVIII, 587 *et seq.*)

The following letter from Dr. S. Kneeland was read:

Apropos of the "Sea Serpents," alluded to at the meeting of Jan. 2, I will relate my experience with some water snakes which I caught in Manila bay in November, 1881, while undergoing a quarantine of three days. We were anchored about three miles from land, in water twenty feet deep. To while away the time we fished, but either our tackle was too clumsy or our bait unsuitable, for we had not even a bite all day.

As night came on we kept our lines in the water, merely for experiments' sake without the remotest idea of catching anything. The sea was calm, and the darkness intense. Between 9 and 10 P. M. we caught six water snakes on hooks of large size, baited with salt pork, and resting quietly on the bottom. They were of about the same size, 3 feet long, with small head and neck, but very thick and strong body; scales thick, rough, and sharply ridged and edged; body compressed laterally; tail wide and flattened, making an excellent swimming organ. General color blackish brown, with yellowish white bands on the sides. These snakes are often seen in the bay, swimming with the head above the surface to breathe; they are sluggish in their motions, progressing by lateral undulations of the body. They probably come down into the bay, which is salt, from the river Pasig, in which I have often seen them where the water is fresh. They were very savage, snapping at everything within their reach with a mouth well provided with small teeth of uniform size. The natives believe their bite to be dangerous, and such is the usual opinion in regard to the *Hydrophidæ* or water snakes.

That they have natural constrictor powers, like the anacondas and boas, I judge from the fact that while holding one suspended by the hook in its mouth, its prehensile tail by accident was inserted in the ring of the heavy steamer lantern which we were using on deck; the tail instantly closed around it, and so tightly that I raised by it the heavy lantern, at least 15 lbs. in weight, and kept it up until I could hold it no longer.

It would be interesting to know precisely what is the modification of the organs of respiration and circulation, which enables these animals to remain so long under water, and to be feeding in utter darkness in such deep water.

GENERAL MEETING, MARCH 19, 1884.

The President Mr. S. H. Scudder in the chair. Thirty-two persons present.

The following paper was read :

ON THE USE OF POLYNOMIALS AS NAMES IN ZOOLOGY.

BY S. GARMAN.

AMONG the Aimaras and Quichuas, Indians of Peru, the names of animals are very often mere imitations of the sounds or cries they utter. A certain bird is called "Leke leke," another "Pocoo pocoo;" and these names as pronounced by the natives distinguish with much accuracy the birds to which they are applied, for one who has seen and heard them. Without special demand for conciseness, as in writing and printing, the length of the name is often increased at the will of the speaker by repetition. Probably many of the earliest names originated in similar practice. In the earlier literature, whatever may have been their origin, the names are generally more concise, most often monomials, and in many cases they are still in use as names of more or less comprehensive groups. Previous to the sixteenth century, knowledge did not call for very close distinctions, and such names as Canis, Felis, Falco, and Bufo were sufficiently definite. Afterwards as differences in the kinds of dogs, cats, falcons, and other animals came to be recognized and recorded the binomial was commonly used. The genus was subdivided and such names as Raia laevis, Raia aspera, and Raia oxyrhynchus became numerous. Further increase of knowledge, accompanied by desire to make names as suggestive as possible and by lack of system, lengthened the names and introduced a vast amount of confusion. Names such as Sciurus virginianus cinereus major are not rare in the literature of the century immediately preceding Linné. In the work of Artedi we find the most suggestive designations as well as the best attempt at system. Here the generic name is followed by an enumeration of characteristics amounting to a short description; "Coregonus maxilla superiore longiore, pinna dorsi ossiculorum quatuordecim," for example. Convenience aside, this method worked tolerably well when the describer knew a number of individuals or when the species was well known, but when represented by a single specimen the species was frequently unrecognizable. For purpose of reference in literature it was necessary to use numbers. The introduction of the binomial system by Linné, or the introduction of system and the return to binomials, secured an amount of convenience in length of the names that much more than compensated for the loss of some of their suggestiveness, and brought about a general agreement in their use and a degree of permanence which contributed greatly toward the dissemination of science. The contraction which names underwent is illustrated by the case of the Coregonus cited above, which became Coregonus lavaretus, Linn. Recognition of plants and animals by their scientific names has become more and more general since Linné's time. There was hope that in time these names would displace the vernaculars. Lately, however, the progress of science is marked by subdivisions of species and variety, subdivisions which demand record in names. It is claimed by some that the trinomial system is better adapted to the science of the present. If the present only were to be considered we should have little to say. The important question is how can we best adapt present science to future use. Evidently the trinomial is only sufficient to the day.

According to recent lists all names are to be trinomials, either through duplication or addition. Cinosterum pennsylvanicum pennsylvanicum, for instance, is suggestive of a step backward toward the repetition by the Aimara Indian. Cinosternum pennsylvanicum doubledayi, is another example. Compared with the binomial there is in the trinomial a manifest increase in inconvenience on account of length. The stability or permanence of the name is decreased by the addition of an element liable to change or displacement on account of differences of opinion. Even if it were adapted in other respects to the needs of science in the present and the future, it is a question whether the trinomial compensates for loss of permanence and convenience. It is apparent to those who make studies of species that it will not be long before increase of knowledge will demand subdivision of varieties, and that reasons similar to those now used in favor of trinomials exist and will be urged in favor of quadrinomials. Certain ornithologists assert that the end has come with the trinomial, that further subdivision is unnecessary. They admit that varieties of varieties exist and are distinguishable, but, like writers of a short time ago who would not notice varieties, they do not consider them worthy of attention. The following quotation from the Auk, April, 1884, p. 202, gives an idea of their attitude in regard to pursuing their own route farther than they have decided to lead us: "There are also many local variations that are not too slight to be detected but which are either too slight or too inconstant to require recognition. . . . While theoretically it is possible to recognize 'varieties of varieties,' in practice this rarely occurs, and should never be countenanced; if a form is different enough to be recognized, it should stand as a variety of the common stock, not as a variety of a variety although it may be more nearly related to some one of several varieties than to any of the others. . . . The recognition of a variety is a matter to be as carefully and conscientiously considered as the recognition of a species or any higher group." The recognition of varieties of varieties "should never be countenanced"! Why not? If they exist, as is acknowledged, we cannot do otherwise than recognize them; they must be recognized and will be named and recorded. Knowledge of the whole species or group being made up of that of its parts, the recognition of a variety of a variety becomes "a matter to be as carefully and conscientiously considered as the recognition of a species or any higher group." A classification in which varieties of varieties are arbitrarily placed as varieties of the common stock is not one to be accepted as a natural one. Yet the author quoted above rightly says "the object of classification in zoölogy is to express the natural or genetic relationship of the object classified," *l. c.* p. 201.

The derangement of the binomial by the recent changes affects not only the name itself but also the clews usually given as aids in tracing the history of the animal to which the name belongs. In the practice of advocates of the tri- or polynomial system its adoption necessitates changes in the authorities. Amblystoma jeffersonianum for which the authorities are Green, for the species, and Baird, for its position in the genus, becomes in the trinomial form Amblystoma jeffersonianum jeffersonianum (Green) Cope. Baird, the authority for the identification of the species as an Amblystoma, is dropped for the name of the duplicator. This change deprives us of a clew to the work of Prof. Baird in connection with this species. To take another example, Diadophis punctatus pulchellus (Linn.), Yarrow, is a Californian variety of the species named by Linné Coluber punctatus. Originally this variety was described by Baird and Girard as Diadophis pulchellus. Linné knew nothing whatever about it; it is a form he never saw, and, if he had seen it, he would have been very unlikely to have considered it distinct. In the trinomial there is no clew to the describers of the form, the authorities for its existence. For punctatus we can go to the twelfth edition of the Systema; but if we take pulchellus it may be that the authority given for the combination will lead us to a list of species to find that all that has been done by this authority has been to place the names together, without indicating the sources whence they are derived. Unless three authorities are given with trinomials, four with quadrinomials, and so on, the work of tracing the history is greatly increased and becomes practically impossible to any one except the specialist. Such a method puts a premium on changes and offers inducements in favor of instability, by an appeal to the vanity of would-be authorities, which will not prove ineffectual. Some trinomialists disclaim responsibility for the repetition or duplication, and say they have been betrayed by their disciples.

The great aim of science being the diffusion of knowledge, it is apparent that the more convenient, permanent and suggestive the shape in which knowledge is put, the more easily it will be diffused among men. In zoology the names are but symbols. Those symbols are most perfect which are at once most convenient, most permanent and most suggestive. Symbols of this character would represent as far as possible our knowledge of the animals to which they were applied. If inconvenient they would not be so easily thought, spoken or written ; if not permanent to some degree they might not continue in use long enough to receive general recognition, and thus they would introduce confusion and doubt as to fact ; and if not suggestive they would compel the student to depend on previous knowledge or subsequent tentative search for clews to identity and history.

Objections to the use of polynomials, including trinomials as now used by some, are that they are inconveniently long, that they are less likely to be permanent than binomials, that they do away with certain advantages derived from long use of the latter, that they increase the labor of tracing, and that they are less suggestive as clews to history, etc. The binomials introduced by Linné, though less suggestive in some respects, were so much more convenient that they at once supplanted Artedi's names in which concise descriptions occupied the place of the specific title. Following the polynomial idea to its logical sequence we should have binomials for species not subdivided, trinomials for such as have varieties, quadrinomials for such as have subvarieties, and so on. One animal or plant would have a name of two words, and its closely allied neighbor might have one of three, four or half a dozen. To secure uniformity in the length of these names, repetition is the only alternative. A system of such possibilities is not to be adopted hastily. The opportunity it affords a writer to replace the name of the preceding authority by his own, whenever by duplication, displacement or addition he may change the name of a species, does not enhance its value.

I have already, in a list of Batrachia and Reptilia, as an answer to the assertion that "there is no other or better method," partially suggested one which affords the means of retaining the binomials, making them indicate the subdivisions recognizable only by the expert, and at the same time fixing upon forms seen without close comparison to be distinct names at present more or less familiar to the general observer from long use. Take for purpose of illustration a single species including several varieties. Each of the forms may be represented by the generic and specific names preceded by a symbol indicating the subdivision and its extent. The symbol represents the history, the description and synonymy of the race or variety; it appeals to the specialist in particular. In the list a species would appear thus:

AMBLYSTOMA TIGRINUM Green; Baird.

(A) *Salamandra tigrina* Green, 1825, Jour. Phil. Ac., v, 116.
(B) *Amblystoma bicolor* Hallow., 1857, Pr. Phil. Ac., 215.
(C) *Amblystoma mavortium* Baird, 1849, Jour. Phil. Ac., Ser. 2, I, 292.
(D) *Amblystoma californiense* Gray, 1853, Pr. Zool. Soc. Lond., XI, pl. 1, etc., etc.

Desiring to call the attention to the fourth form, it is not necessary to spell it out; it is simply the (D) form, and is to be written (D) Amblystoma tigrinum. As it precedes the name, the symbol catches the eye at once and shows that it is a variety of the species and not the species itself which is dealt with. In this position it is out of the way of the abbreviations used to note the authorities, and being a letter it cannot be confused with the number of specimens. The order in which the letters are given is immaterial. The (B) may be nearest the (A) in order of discovery, or it may not; it may be nearest in affinity, or it may not. There are chances that (K) or (M) may be found to have been discovered previously; or a form discovered to-morrow may be more closely allied to (A) than (B), (C) or (D). A chronological or genetic arrangement of to-day may be disarranged by discoveries of to-morrow. Until our knowledge of the species is more complete we cannot hope to make an arrangement that will be permanent; consequently it is as well to start with the understanding that the order of the letters means little more than that the forms occur in the same order in the list or synonymy, which order may be changed in various ways by a genetic or a chronological arrangement. Thus far we have dealt only with varieties or subspecies. Suppose the specialist to discover that (C) A. tigr. is composed of several subvarieties. What change shall be made in the name that it may at once show to the expert that he is dealing with one of several local races, and at the same time point out to those whose knowledge is not so special, that it is a species with which they may be acquainted under the specific name of the common spotted salamander west of the Mississippi Valley? Suppose farther that a student has named one form nebrascensis, another has noted a form as hallowelli, and a third one as parvimaculatus (possibly through misinterpretation of individual variation); they can be designated (C^a), (C^b) and (C^c) Amblystoma tigrinum. A further subdivision could be marked (C^{a1}), (C^{a2}) A. tigrinum, Green; Baird, and, again, subdivision of these ($C^{a1'}$), ($C^{a1''}$), etc., the equivalent polynomial for one of which might stand as spelled out, Amblystoma tigrinum mavortium hallowelli maculatissimum suspectum. The advantage of the contraction ($C^{a1''}$), Amblystoma tigrinum, for general literature is apparent. Again, varieties exist which possess characters of one or more other varieties. A case of this character can be marked by placing together the symbols of those varieties to construct that of the new one, thus: (AB) or (AE) Amblystoma tigrinum or in more complicated case of relationship, thus: (B^a C^{b1}) Amblystoma tigrinum, and so on. Though the symbol is for the benefit of the specialist, the designation of the species remains the same in all cases for the advantage of the general student. The authorities for the genus and species are retained as in common use. Should it be desirable to note the responsibility for subdivision and combination, it can be done thus: (B) A. tigrinum (Green, Baird) X, Y; *X* being responsible for the variety and *Y* for the combination.

Enough has been said to indicate the possibilities of the method. Among its special points are these: the name of the species, a form more likely to be recognized by the general or ordinary observer, retains a more convenient size, is more permanent and at the same time records the steps in the work of the special investigator; the more desirable of the authorities are retained; subdivision when necessary is not prevented by dread of long names; the symbol, preceding the name, is not to be overlooked or confused with the abbreviations for authorities; more complex relationships can be indicated as readily as the more simple.

Of course it is not expected that we shall soon have use for five or six or more subdivisions, but we should build for time to come. Unless a system is soon to be thrown aside as useless it must be prepared for the needs of the future. Whether the trinomialist agrees or not, the recognition of varieties of varieties or of varieties of subvarieties will be countenanced. His objections to subdivision are only new forms of those put forward against making varieties of species a short time ago. Research is not at all likely to end when the capabilities of a trinomial system are exhausted. No doubt any system that may be devised will be imperfect enough, yet this would be a poor reason for adopting one that is evidently but a makeshift for present use.

Mr. C. O. Whitman discussed the various theories of the origin of vertebrates, advocating their annelidan ancestry.

Dr. G. L. Goodale showed a collection of vegetable monstrosities arranged according to Dr. Masters' classification, and prepared by Mr. Herbert Watson.

GENERAL MEETING, APRIL 2, 1884.

The President, Mr. S. H. Scudder, in the chair. Twenty-five persons present.

Prof. G. Frederick Wright gave an account of his last summer's field work in tracing the continental terminal moraine through Indiana, and discussed the effects of a glacial ice-dam across the Ohio at Cincinnati.

Professor E. S. Morse described the various methods of ancient and modern arrow-release, defining four principal types, North American, Indian, Saxon, Asiatic and Malay, each showing some variety.

Dr. Hagen read a paper on the Hessian fly, showing from the records of the American Philosophical Society, that the fly bore this name before the Revolution.

General Meeting, April 16, 1884.

Ex-President, Mr. T. T. Bouvé in the chair.

The following paper was read:

ON THE RELATION OF THE "KEWEENAWAN SERIES" TO THE EASTERN SANDSTONE IN THE VICINITY OF TORCH LAKE, MICHIGAN.

BY M. E. WADSWORTH.

At the present time it is well known that in their typical condition the copper-bearing rocks of Keweenaw Point consist of a series of lava-flows, sandstones, and conglomerates, piled one above the other and dipping in a northwesterly direction.

On the eastern and western sides of the series the fragmental rocks are most abundant, while in the central portions the lava flows are the predominating rocks, which oftentimes followed one another without any intervening conglomerate. Wherever the lava poured over the earlier detrital rock it baked and indurated it, while in every case the conglomerates and sandstones are found to be laid down on the eroded surface of the underlying lava flow, whose debris is seen mingled with the old rhyolitic, trachytic, and granitic material of which the conglomerate is chiefly composed. This alternating action of sea and lava went on from the beginning to the end of the series, the relative proportion of the detrital material to the lava depending upon the rapidity of the succession of flows. There was thus produced between every flow and between each flow and its underlying and overlying rocks complete unconformability the same as everywhere exists when eruptive rocks reach the sea—an unconformability which indicates sequence of time but not difference in geological age.

The one vexed question over which geologists have been exercised is: are these copper-bearing rocks pre-Potsdam or not? On every hand it has been admitted that the sandstone to the eastward of those rocks on Keweenaw Point is of Potsdam or more recent age—the weight of authority being at present in favor of the Potsdam. Again the relation of that sandstone to the intercalated lava-flows, sandstones, and conglomerates is looked upon as decisive proof of the age of the lava. Two strong parties of geologists have discussed this question—one claiming that the eastern sandstones were of the same age as the lava flows, the other that the latter formed a distinct and older series.

The principal evidence in support of this latter opinion was obtained at the Douglass Houghton Falls near Torch Lake. Here it was stated that the horizontal eastern sandstone extended up to the base of the falls, the rock forming the cliff over which the river runs being the old basaltic lava. It was further declared that the cliff at the falls formed an old seashore bluff and that the sandstone and conglomerate abuting against this contained its water-worn debris. Here on its face was good evidence that the traps were older than the eastern sandstone and of greater geological age. This was the only evidence of importance that originally caused the copper rocks to be named Keweenawan and regarded as pre-Potsdam.

In 1879 the present writer examined this locality, studying not only the bed of the stream but also the steep banks of the ravine below the falls. He found that the accounts of the structure here, that every geologist who had examined the district for thirty years previously had given, were according to his observations incorrect. The sandstone was not horizontal or at most dipping from one to five degrees, but the dip gradually increased up to 25°, until the falls were reached. Furthermore these northwesterly dipping sandstones and conglomerates, that every one until that day had conceded to be truly the eastern sandstones were found to contain intercalated lava flows and to possess the structure of the typical copper-bearing rocks. These observations fully explained the occurrence here of the basaltic debris, and showed that it came from the underlying lava flows instead of from the hypothetical seashore bluff. These observations also proved that at the birthplace of the "Keweenawan Series" that formation and the "eastern sandstone" were one and the same.

This evidence has been recently examined by Professor R. D. Irving and the results published in the "Third Annual Report of the United States Geological Survey." Irving, who was and is a warm advocate of the integrity of the Keweenawan Series, admits the correctness of my evidence and argues that for some distance below the Douglass Houghton Falls the copper-bearing rocks exist, as stated by myself. He then abandons the idea that an old shore bluff exists at the falls but places such a cliff some distance below nearer the lake. Irving states that the rocks are here covered for some two hundred paces, but that below this space the eastern sandstone appears dipping from two to five degrees. He also asserts that I bridged in my imagination this covered space, and united without evidence this low dipping eastern sandstone with the more steeply dipping Keweenawan series below the falls; this however did not prevent Irving's imagination from placing between the two observed points the hypothetical sea-beach cliff, which other observers had placed above at the falls. If we carefully read Irving's published works it will be seen that he no more knows that the sandstones below the covered gap are distinct from the rocks above, than I do that they are the same, according to his own statement of my observations. Since the question now turns upon the manner in which my observations were made, it is important to know how our geologist in Wisconsin could allow himself to state so positively what I did in that ravine walled by high banks and concealed in the forests of Northern Michigan? For his statement that I imagined the connection between this eastern sandstone and the so-called Keweenawan Series is entirely erroneous; since the sandstone seen by me to dip five degrees to the northwest I found, by digging in the stream and on the sides of the ravine, to underlie others, and those in their turn were traced by digging until it was proved that all formed a continuous series with a gradually increasing dip up to the falls themselves. By actual inspection of the uncovered rocks and their superposition above one another, the writer proved then that no such bluff, as Irving imagines, exists in the locality.

It is to be remembered that the exact spot at which the Douglass

Houghton Falls are situated is the typical one on which the Keweenawan Series was founded; and now when my observations have showed the erroneousness of the evidence said to have been found there, Irving changes the boundary of the series and places it in a covered district some distance below, a locality in which no one before dreamed of imagining the limit of the series to be. Since he has reckoned incorrectly on my method of observation, it will now be necessary for him to move the boundary line still further to the eastward. I protest against such methods, for if a geologist can change the limits of his formation at will, in order to save it, one will have to dig a canal across Keweenaw Point and tunnel under Lake Superior before this question can be settled.

Another locality in which the eastern sandstone and Keweenawan Series were shown by myself to be the same formation is on the Hungarian River, flowing into Torch Lake. Irving, following later, has stated that the sandstone and conglomerate often lie horizontally, sometimes dipping slightly northwest and at others southwest. From his language and section it may be seen that his observations were made on the more or less undermined blocks on the banks, and he states that he failed to find any evidence of an increasing northwesterly dip but a general horizontality. Also that the sandstone beneath the first lava flow of the Keweenawan Series is probably a fallen block but if it is not, the overlying lava flow certainly is.[1] It now becomes necessary to give the basis of my evidence as published. My observations were made chiefly in the bed[2] of the stream, the water being at that time exceptionally low so that the rocks were traced continuously. It was found here that in general, when the sandstone and conglomerate were undisturbed, the dip increased from 10° to the northwest up to 15°, to 18°, and 20°. Quaquaversal dips were seen and noted but the prevailing dip obtained on the undisturbed bed rock was found to be as given above. Instead of the sandstone in the bed of the river, next to the lava, being a loose piece, it was found to extend across the stream at the fall and into both banks; also it was continuous with the sandstone farther down the stream. Now this sandstone was baked and indurated by the overlying flow of lava at the foot of the fall, the same as the sandstones are elsewhere in the Keweenawan Series where the lava rests on them. Further, this lava mass is not a loose piece because it had not only indurated the sandstone, but it was also found to extend across the stream into both banks, and to underlie the conglomerate forming the fifth fall of the stream; while the detritus of this lava was dug out of the base of that conglomerate by myself and is now preserved in the collections of the Museum of Comparative Zoology. All this conclusively shows that the sandstone in question is a constituent portion of the eastern sandstone, that it was overflowed and indurated by the basaltic lava now lying there and admitted to be a constituent portion of the so-called Keweenawan Series; and further that this lava flow was denuded and its detritus built into the overlying conglomerate which in its turn was overflowed by another lava stream.

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[1] *l. c.* pp. 149-151, 153-155.

[2] This Irving marks on his section as unexposed.

It is still maintained that this evidence, published with sufficient fulness in 1880,[3] demonstrates that the eastern sandstone here is a constituent part of the copper-bearing rocks and underlies them; also that the Keweenawan Series, as first established, has no existence as a distinct formation older than the sandstone.

It is to be distinctly remembered that Irving's evidence consists solely in the fact that he has not seen, or negative evidence, while mine is positive or a statement of things seen, and therefore by all laws of evidence leads. In other words the whole question depends upon this: did I see that which I affirm I saw or not? If I did, and no one has proved that I did not, then the Eastern sandstone underlies the copper-bearing rocks on the Hungarian and Douglass Houghton Rivers, and the Keweenawan series, as now held, is an impossibility. It can hardly be considered egotism if I claim, considering the history of events since 1878, that my statement that I have observed a certain fact is at least as good evidence as the statement of some others that they have not seen the same. In the district in question one of the favorite arguments advanced by a number of observers in favor of the essential difference in age between the eastern sandstone and the traps has been that the detrital rocks intercalated with the latter are largely composed of old rhyolitic and trachytic debris, but that the eastern sandstone is composed chiefly of quartz. Since the rhyolitic and trachytic material is eruptive, its absence proves nothing regarding difference in geological age in sandstone formed fifteen minutes before the beginning of these eruptions. However, it was pointed out by me in 1880 that the eastern sandstone (now admitted to be such) did contain this debris on the Hungarian River[1] and elsewhere.

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[3] Bull. Mus. Comp. Zoöl., VII, 113–116.

It was also pointed out that the colorless condition and the absence of argillaceous material in the eastern sandstone at *some* points was due to bleaching by thermal waters which had likewise bleached and destroyed the felsitic material in portions of the conglomerates and sandstones now admitted to belong to the Keweenawan series (l. c., pp. 116, 117).

It was further pointed out at the Sandstone Quarry near Torch Lake, that while the sandstone was composed in part of the same materials as those found in the sandstone in the Marquette district, that it also contained a large proportion of short hexagonal crystals of quartz, terminated by pyramids at both ends, the same as the quartz grains are in the old rhyolites (quartz porphyries) in the Keweenawan series. It was further shown that the horizontal so-called bedding planes of this sandstone were joint planes, while the true bedding planes were determined by numerous coarser layers of sand, pebbles, clay masses, etc., which extended long distances approximately parallel to one another at an average dip of N. 45,° W. 15.° It was again stated that this sandstone had been subjected to thermal waters and the felsitic[2] material had been converted into clay or removed.

While part of the clay masses are distinctly altered pebbles, others which were not taken into account in determining the dip are probably formed from infiltrated clay. Irving throws doubt on the correctness of the above observations by stating he cannot find the same evidence and claims that while he finds traces of the trappean material in the sandstone he finds none of the porphyry material belonging in the conglomerates of the Keweenawan series. This last proves too much, for if as he claims this sandstone must have been deposited against the mixed lava flows and detrital rocks and made up of their ruins, then it should be full of their debris, and the old rhyolitic and trachytic material ought to be far longer retained than the more easily perishable basaltic material. The basaltic debris, indeed, is comparatively rare even in the midst of the copper-bearing rocks. Irving's testimony is directly opposed to his own views, as also is the testimony of all those who claim that the sandstone near the traps is composed of different material from the detrital rocks of the so-called Keweenawan series.

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[1] Irving admits this in his Final Report, p. 354.

[2] Misprinted feldspathic in Bull. Mus. Comp. Zoöl., 1880, VII, p. 117.

I have, while writing this, before me, under the microscope, sand from this Torch Lake sandstone which shows the structure of the quartz stated. The bi-pyramidal quartz has since been found by Irving, who however considers that it has been produced by the secondary enlargement of rolled quartz grains (Bull. U. S. Geol. Surv., 1884, No. 8, p. 41.) At the time of my observations Sorby's Presidential Address, which Irving makes the basis of his studies on the secondary deposition of quartz, had not been published, or at least been seen by me. I made my observations simply by examining the dry sand in air under a lens and by the lower powers of the microscope. I have never recurred to the subject since except at the time of writing the above paper, when my examinations were made as before, simply to see if I had been mistaken in observing the bi-pyramidal forms. Now, however, owing to the publication of the Bulletin above referred to by Messrs. Irving and Van Hise, I have prepared mounted sections especially for the purpose of testing the correctness of Irving's supposition. These preparations fully confirm his views as to the secondary origin of the quartz facets deposited on the rolled quartz. I therefore entirely retract all of my conclusions based on the observed pyramidal forms. In order to ascertain the derivation of the quartz grains, sections were ground and mounted in balsam, so one could see if they internally presented the structure of the quartz of the Copper-bearing felsites or not. None of the bi-pyramidal inclusions were observed (Bull. Mus. Comp. Zoöl. 1880, vii, 120), but numerous fluidal cavities and in some grains many of the hair-like trichites so commonly seen in the quartz of granites and in many of the conglomerate pebbles of Keweenaw Point were found. The evidence is far from being decisive whether this sandstone is composed entirely of the detritus of the Azoic rocks or in part from the debris of eruptive rocks similar to those in the Keweenaw conglomerates. While the facts only are to be sought, yet I am very much pleased to be able to confirm Professor Irving's observations and to amend my conclusions, for if this sandstone is composed entirely of Azoic debris it is in perfect accord with my observations that the eastern sandstone underlies the copper-bearing rocks, and is opposed to Irving's view that it abuts against these rocks and is made out of their ruins. I also have before me specimens that were selected in the quarry expressly to show the difference between the true bedding planes and the joint planes. This angle as measured on one specimen is about 18°, but in others it is less.

Irving is further mistaken in his statements that he was the first to point to the presence of acid eruptives in the so-called Keweenawan series, and that Foster and Whitney regarded all the acid or jaspery rock as metamorphosed sandstones, and all the conglomerates and sandstones as friction detritus.[1]

I further have reason to object to Professor Irving's general method in the first part of his report inasmuch as it is written so as to convey to persons not familiar with the literature of Lake Superior geology, the idea that he was the first to microscopically study the Keweenawan felsites, granites and quartz-porphyries, when instead they were first so studied by myself.[2] There is all the greater reason for a protest against such a method of writing since I have evidence that it has resulted in misleading persons in the past. Still I have no complaint to make of the latter part of Irving's report or of his papers since 1883, on this score. In the final report, however, Irving makes statements regarding the views of Foster and Whitney, and my writings, that are so incorrect, that it is difficult to find excuse for them, except on the supposition that he quoted us from memory, and that his memory is defective. Again Irving's statements of the views and labors of others are often incorrect or partial and misleading. I may cite for examples the assertions that Rivot only had maintained the metamorphic (sedimentary) origin of the traps; that Pumpelly and Marvine first recognized definitely that the amygdaloids were the upper portions of the trappean beds; that Marvine made the first plainly and thoroughly worked out argument from structural characters alone in favor of the lava-flow origin of the traps; that

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[1] Geology of Lake Superior, Part I, 1850, pp. 58, 59, 70, 71, 78, 79, 103, 109.

[2] Irving has partially rectified this in a foot-note appended to his final publication, issued since this paper was read.

Wadsworth maintained that Foster and Whitney were the only authors who had written correctly on Lake Superior geology; also I may further cite Irving's charges that Wadsworth did not dare to point out wherein he disagreed from Foster and Whitney, and that he did not render due credit to Pumpelly and Marvine. All of the above statements of Irving I pronounce entirely incorrect, as any one can see who cares to read my work on Lake Superior geology with care. Therefore I need not discuss the matter further except in Marvine's case to simply say that I was the first, so far as I am aware, to publicly call attention to the great value of his Lake Superior work. While I frankly disagree from Professor Irving in the above points and some others[1], I yet recognize the great merit of his work in other directions and find myself there in full accord with him.[2]

ANNUAL MEETING, MAY 7, 1884.

The President, Mr. S. H. Scudder, in the chair.

The following annual reports were presented:

REPORT ON THE MUSEUM. BY A. HYATT, CURATOR.

As in former reports, we have still to lament the melancholy state of our finances and our inability to do work such as this Museum is fitted to do for the benefit of the community.

We wrote last year that we hoped to be able to establish loan collections for circulation, basing our idea of the need of such collections upon the constant demands for specimens which are made but have to be denied by us. We have held for years past that the time must come when people would realize the necessity of seeing

[1] See further Science, 1883, i. 248, 249, Bull. Mus. Comp. Zoöl., vii. 482–498.

[2] Concerning the replacement of feldspar by prehnite in coarsely crystalline diabase, to which attention is called by Irving in the final report (pp. 40, 43) his case may be strengthened by the fact that like change in a very coarsely crystalline diabase of Massachusetts was pointed out by the writer in 1877, Proc. Bost. Soc. Nat. Hist., 1877, xix, 228, 229.

the things themselves, and be as eager to know them by sight as they are now to read descriptions of them in books. It will not take many years of such training as is beginning to be given in some of our public and private schools to bring a multitude of the more intelligent minds to this stage. The progress of the past few years has been slow, but it is substantial and encouraging, and that of the next decade will probably be much more rapid. After that, if the same law holds in education as in the history of other events, we must anticipate a demand for natural history instruction greater than our imaginations would now consider reasonable.

Mineralogy.

Prof. W. O. Crosby returned from Europe in October and resumed his duties as an assistant in the Museum of the Society. A large proportion of his time has been absorbed in the preparation of a Guide for the mineralogical collection. The difficulties which are to be encountered consist in the mixed purposes of the collection. This is devoted not only to the exhibition of objects, but also aims to make them directly useful to teachers and students as illustrations of natural laws and relations. Thus we can appropriately use neither a text book, nor an ordinary form of guide, and we have had to learn this fact by actually writing the guide first in the text book form, and thus, by experience, proving that it would not answer. Prof. Crosby, assisted by Miss Carter, during the past winter, catalogued and mounted all of our New England minerals, but this part of the collections of minerals is still too imperfect to be worthy of a final report.

Prof. Crosby has given twenty-five specimens of minerals selected from his European collection.

Geology.

In the last annual report it was stated that our want of means would probably seriously interfere with, if not prevent, the completion of the rearrangement of this department. These forebodings have been unfortunately fully verified, and the collections remain as they were two years since, when apparently advancing rapidly to their last stage of preparation. The materials on hand will enable us to bring forward most of the departments to just about the same condition, and then, as in the present instance, if not supported by donations for the purchase of specimens and the employment of labor, they cannot be effectively completed.

Mr. Crosby has added to the lithological collection about 75 specimens of volcanic and stratified crystalline rocks, collected in Europe; also several large specimens of lava illustrating important points in structural and dynamical geology.

Botany.

Under the direction of Mr. Cummings, Miss Carter has continued the revision and relabelling of the general collection of plants, and has finished the Gamopetalous orders. These now contain 41 orders, 974 genera, and 4524 species. The bundles of dried plants containing 7270 specimens laid aside by the gentleman formerly in charge of this department and supposed to be only duplicates of the Gamopetalae, have been reëxamined, and 1116 specimens representing as many species and varieties, which were not in the general collection, have been picked out and restored to their proper places. A small but interesting collection of thirty-six species of the fruits of native forest trees, accompanied by water color sketches of the flowers of the same species, has been presented to the Society by Miss E. M. Jack of Chateauguay Basin, Canada. Some of our members may possibly remember this collection, as having been on exhibition in the Woman's Department of the New England Mechanics Fair last year, where Miss Carter saw it and obtained it as a donation from the exhibitor. The New England herbarium is indebted to Miss C. H. Clarke for 16 species of Algae. Mr. E. T. Bouvé has continued to take an interest in this department and has added a number of specimens to the interesting and valuable collection of trees and shrubs of New England which the society has already received from him.

Anatomical Collection.

Mr. Henshaw has expended much time upon this collection, and the whole has been rearranged, and the labels revised. It has been found to contain about 1700 preparations, many of them representing delicate injections, and interesting points in the anatomy of the vertebrata.

Some sections of skulls and limb bones have been added, all the specimens mounted and catalogued, and many labels prepared. Large descriptive labels have also been printed explaining such topics as the homologies of the skull and limb bones and the bones themselves correspondingly lettered. About half of the material not on exhibition has been arranged and classified, and it is anticipated that Mr. Henshaw will be able to make a final report next year.

Synoptic Collection.

A few Blaschka models of Coelenterata and Worms have been acquired by purchase.

Miss Martin has made preparations exhibiting the external skeleton of six of the orders of insects, and has begun to work up the illustrations intended for the exposition of the structure and affinities of the Protozoa.

Mr. Henshaw has completed the mounting and cataloguing of the osteological and anatomical preparations of the Vertebrata. The descriptive labels for about two-thirds of this part of the collection have been printed, and the labels of the oölogical specimens prepared for printing.

Sponges.

Mr. Henshaw has completed the labelling and Miss Martin the mounting of the Keratosa, which have been monographed, and published in the memoirs of the Society. Mr. Henshaw has also completed the cataloguing of the whole of the collection now on exhibition.

Mollusca.

Mr. Henshaw has spent a very large proportion of his time upon this collection. He has gone over and arranged the miscellaneous accumulations, about one-third of which have been placed in good condition. During this process one hundred species representing fifty genera, mostly pulmonates, were found, named, labelled and added to the systematic collection. The internal aspect and general structure of shells have been illustrated by a few sections prepared by Mr. Henshaw. Miss Martin has also spent considerable time on this collection, in dusting and remounting the specimens on exhibition, and other miscellaneous work.

Crustacea.

Mr. Kingsley has been kind enough to continue his work upon the valuable collection which he so generously gave the Society. He has finished the revision of a part of the entire number of bottles, and we hope to be able to make a full report next year. Miss Martin, under the direction of Mr. Henshaw, has catalogued and placed in order the whole of the general collection. The dry specimens, including a number of interesting species, representing, in some cases, the types of Randall, Say and Stimpson, have been in a bad condition for several years, and it is a gratification to report them repaired and mounted.

Insects.

Mr. Henshaw reports that one hundred and thirty specimens representing the early stages of fifty-two species of American (chiefly New England) butterflies have been given to the Society by the President, Mr. Samuel H. Scudder. We are also indebted to Mr. Roland Thaxter for a valuable gift of the species of Noctuidae, selected by him in order to fill gaps in our New England collection. Dr. S. W. Williston, of New Haven, has kindly undertaken the identification of the Society's collection of Diptera, and has finished and returned the Syrphidae. There are one hundred and seventy-two specimens representing sixty species, and the New England forms are the first of this order we have ever been able to place on exhibition. Mr. Henshaw has generously given to the Society about 3500 specimens representing one thousand species. These were especially selected to fill gaps in the New England and systematic collections, and were, therefore, very acceptable. Donations have also been received from Drs. Hagen and Dimmock, and Mr. Sheriff.

Fishes.

Dr. H. E. Davidson has finished and presented to the Society eighteen specimens, representing as many species, of his valuable preparation of fishes.

Reptiles.

Mr. Henshaw has identified, catalogued, and labelled sixty specimens, representing twenty-five species of turtles.

Birds.

Mr. William Brewster, who continues to take an active interest in the Museum, has succeeded in obtaining a number of important species not previously represented in the New England collection. We are also indebted to Mr. F. J. C. Swift, and J. M. Wade for gifts.

The rearrangement of the general collection by Mr. Brewster, assisted by Mr. Henshaw, has been completed throughout eight families of singing birds. The duplicates and poor specimens have been weeded out, and the identifications of the North American species and also of the foreign forms, wherever practicable, have been verified.

Mammals.

Three species, including a fine specimen of American Wild Cat taken in Lenox, Mass., and presented by Dr. R. C. Greenleaf, jr., have been added to this collection. A pair of African monkeys presented by Miss R. L. Learned, has been added to the general collection.

Teachers' School of Science.

The liberal action of the trustee of the Lowell fund in defraying the expenses of the lessons, and also in continuing to grant the use of Huntington Hall, has enabled the Society to persevere in its effort to extend the benefit of its instruction in this department to teachers of all the neighboring towns as well as to those living in Boston. The agents who acted in the adjoining towns and villages last year continued their kind offices, distributing and receiving applications and also tickets according to the plan of which details were given in the last annual report. The Superintendent of Public Schools in this city also materially assisted us by attending to similar technical details in Boston, and in his annual report, noticed our work very favorably.

The following extract is taken from that publication.

"Besides the general instruction afforded by these lectures, the teachers find in them valuable practical suggestions as to methods of giving observation lessons and elementary science lessons in school. This school is doing an invaluable work; and the wise liberality with which it has been supported out of the income of the Lowell Institute fund deserves grateful public acknowledgment."

There were fifteen lessons given during the past winter. They consisted of five on the "Elements of Chemistry," by Prof. Lewis M. Norton of the Mass. Inst. of Technology, and were as follows: 1, first principles of chemistry; 2, the chemistry of the air; 3, the chemistry of the water; 4, the chemistry of combustion; 5, the chemistry of the metallic elements. There were also five on the "Practical examination with simple apparatus of the physics and chemistry of vegetable physiology," by Prof. Geo. L. Goodale of Harvard University, and were as follows:

1, vegetable assimilation; the mode in which plants prepare food for themselves and for animals; 2, the kinds of food stored in vegetable organs; illustrations of the starches, sugars, oils and albuminoidal matters; 3, how food is used by plants and animals in the formation of new parts; mechanics of growth; 4, how food is used in work of all kinds by different organisms; 5, adaptation of organisms to extremes of heat and light, chiefly with respect to geographical distribution.

The course was concluded with a series of five lessons on "Chemical principles illustrated by common minerals," by Prof. W. O. Crosby of the Mass. Inst. of Technology.

The lessons began with the usual large attendance of over five hundred, and this number was slowly reduced until the audience averaged less than two hundred. The excessively bad weather had undoubtedly a serious effect upon the last course but less, we think, than the fact that Saturday is not only the teachers' sole holiday, but it is almost all the time that can be made available for study outside of the regular professional work.

Though greatly in need of some leisure which can be devoted to the studies necessary to keep up with the requirements of a progressive curriculum, teachers are as closely confined to professional work as if it consisted, only, of the daily repetition of precisely the same mechanical tasks. A proper and wise forethought should long ago have given them, at least, half a day in every week, besides Saturday, for study, the pursuit of the information needed for teaching new subjects, and other similar matters. The efficiency of the individual teacher would be greatly increased by this expedient, and much more than compensate for the small amount of time lost to the pupil. The decline in attendance at our lessons is not due to the subject, nor to its mode of treatment; it occurs with all lecturers and subjects alike, and evidently arises from the weariness and fatiguing work, which the teachers have to support. This becomes more and more onerous as the spring approaches, and under these circumstances it is highly creditable to the profession that so large a proportion are capable of keeping up throughout the entire course. The average attendance at the first series of lessons, in proportion to the number of tickets distributed, was about thirty per cent, at the second series, about twenty-five per cent and at the third, about fifteen per cent; five per cent of this extraordinary falling off, in the last series, was as we have said, probably due to stormy weather. The following abstracts give the items as taken from the records on file.

Number of applications received 854.

Number of tickets distributed,	
Chemistry	928
Vegetable Physiology	938
Mineralogy	932
	2798
To teachers,	
Chemistry	781
Vegetable Physiology	764
Mineralogy	750
	2295
To others,	
Chemistry	147
Vegetable Physiology	174
Mineralogy	182
	503

LIST BY TOWNS.

	Chem.	Veg. Phys.	Min.
Andover	1	2	1
Arlington	5	5	5
Ayer	1	1	1
Boston	437	426	434
Bridgewater	6	6	6
Brockton	1	1	1
Brookline	21	22	22
Cambridge	65	62	58
Canton	12	13	12
Chelsea	38	39	33
Cohasset	1	1	1
Dedham	10	10	10
Hingham	10	8	8
Hyde Park	23	24	24
Kingston	1	1	1
Lawrence	9	8	8
Malden	9	8	9
Medford	6	7	6
Melrose	11	13	11
Newton	30	31	25
Quincy	23	20	20
Salem	7	7	6
Saxonville	1	1	1
Somerville	5	3	1
Stoneham	10	10	9
Wakefield	15	5	7
Waltham	12	12	12
Watertown	10	10	10
Weston	6	6	6
Weymouth	1	1	1
Woburn	1	1	1
TOTALS	781	764	750

Thirty towns in the neighborhood of Boston.

GRADE OF TEACHERS.

Boston Public Schools,	
Tickets distributed to Superintendent	1
" " " Masters	31
" " " Sub-Masters	28
" " " Assistants	389
Out-of-town Schools,	
Tickets distributed to Superintendents	4
" " " Masters and Principals	81
" " " Sub-Masters	8
" " " Assistants	258

Laboratories.

The laboratory has been used by the following classes: one in Zoology and Paleontology from the Mass. Inst. Technology, one in Zoology from the Boston University, both of these being under the charge of the Curator; also one in Botany and one in Physiology, from the Boston University, both of these last named being under the charge of Mr. B. H. Van Vleck. There has been the usual activity in this department, and its teaching power has been slightly augmented by the addition of selected specimens and diagrams.

The Annisquam laboratory was more useful, and its instruction more highly appreciated, than had been anticipated at the date of the last annual report. The falling off in attendance was much less than had been expected, and we think it has probably reached its lowest point. The introduction of the study of natural science into the schools has taken a definite form, and there is also a revival of these subjects in the curriculum of the Mass. Inst. of Technology. These two sources will furnish some students to the laboratory next summer, and these will increase in numbers in future years, if the department can be kept up to the requirements of the times.

Mr. Van Vleck, who has voluntarily attended to the laboratory and the details of teaching, reports that ten pupils were present, five women and five men. Four of these were teachers in colleges and academies, four were special students of natural history, and two intended to study medicine. The average time was three weeks and a half for each person. The laboratory was opened on the sixth of July, and kept running until the twentieth of September.

It must be remembered also that the laboratory has been very useful to Mr. Van Vleck himself in furnishing him opportunities for the prosecution of his studies, and it is likely to become of value in the future as a station to which an investigator can resort, who wishes to study on that part of the coast.

SECRETARY'S REPORT. BY EDWARD BURGESS.

Membership.

The Society's list of members has fallen off in numbers considerably during the past year. By death we have lost two Honorary Members,—Oswald Heer of Zürich, and Joachim Barrande of Paris; three Corresponding, seven Corporate, and one Associate Members. Two Corporate and five Associate Members have resigned; while five and six of these classes, respectively, have been dropped for non-payment of assessments. Sixteen Corporate and four Associate Members have permanently removed from New England, and their names have, therefore, been taken from the roll. The total loss in all classes is thus fifty-one, while only twenty-three new names have been added to the list, as follows: one Honorary, seven Corresponding, six Corporate, and nine Associate Members. The Society has also lost by death two of its patrons, Thomas G. Appleton and Jonathan Ellis.

Meetings.

The weather on Wednesday evenings, this winter, has been persistently horrible, reducing the average attendance at the sixteen General Meetings to twenty-eight, or five below the average for three years. The largest attendance at any one meeting was fifty-four, and the smallest only four; while on two other evenings only eight and twelve persons were present. Thirty-five communications in all were made at these meetings.

The Section of Entomology hibernated for the season, one meeting only being held by four persons.

Library.

The additions to the library amount to 1951, distributed as follows:

	8vo	4to	Fol.	Total
Volumes,	227	74		301
Parts,	852	277	205	1334
Pamphlets,	254	16	2	272
Maps, etc.,				44
			Total:	1951

Two hundred and forty-six books have been bound.

We have arranged an important number of exchanges, as shown by the following list:—

Seismological Society of Japan, Tokio.

Société Impériale des Amis d'Hist. Nat., d'Anthropologie et d'Ethnographie de Moscou.

Comité Géologique (de Russie) St. Petersbourg.

Revue Géographique Internationale, Paris.

Société Géologique du Nord, Lille.

Muséum d'Histoire Naturelle de Marseille.

Société Française de Botanique, Auch.

Geographische Gesellschaft, Greifswald.

Thurgauische naturforschende Gesellschaft.

Indiana, Department of Geology and Natural History.

Botanical Gazette, Indianapolis.

Minnesota Academy of Natural Science, Minneapolis.

Vassar Brothers Institute, Poughkeepsie.

Tromso Museum, Tromso.

Four societies formerly among our correspondents, but which had for some years ceased to send their publications in exchange, have again consented to renew their relations with us. These are the Berliner Gesellschaft für Anthropologie, Ethnologie und Urgeschichte, Verein für Naturkunde, Cassel, Société Linnénne de Normandie, Caen, Reale Accademia di Scienze, Torino.

The Society is indebted for valuable gifts to its Library, to Messrs. S. H. Scudder and Samuel Henshaw, and also to the following Societies for large series of their publications:

Société Géologique de France, Paris; Société de Géographie, Paris; Société des Amis d'Histoire Naturelle, d'Anthropologie et d'Ethnographie, Moscou; Allgemeine Schweizerische Gesellschaft f. d. gesammten Naturwissenchaften.

Eight hundred and forty books have been borrowed from the Library by one hundred and nine persons.

Publications.

The Publishing Committee has published three parts of the twenty-second volume of Proceedings. Of the Memoirs the chief article published is the essay on the embryology of Oecanthus and Teleas, by Mr. Howard Ayers, to which the first Walker prize for 1883 was awarded. This essay forms number VIII of vol. III. 56 pp. and 8 plates; numbers VII and IX containing farther contributions by Mr. S. H. Scudder to our knowledge of fossil insects have also been published, and number X, containing notes on the life history of the peeping frog, by Miss M. H. Hinckley, has just been issued.

Walker Prizes.

The annual prize for 1883 for the best essay on the life history of any animal was awarded to Howard Ayers of Fort Smith, Ark., and his essay has been published as just stated. The second prize was divided between the authors of two papers of equal merit: Mr. H. W. Conn of Baltimore for an essay on the development of Thalassema, and Mr. Wm. Patten of Watertown, Mass., for one on the embryology of a Phryganid[1]. Lack of means prevented the publication of these two important papers.

The same subject, the life history of any animal, extended to include the life history of any plant, was announced for this year's prize, and two essays have been offered.

The present year being that for the award of the third Grand Honorary Prize, the Council last December appointed a committee consisting of Dr. Asa Gray of Cambridge, Prof. S. F. Baird of of Washington, and J. S. Newberry of New York, to recommend the names of one or more persons as worthy of the Prize. Their report was duly made, and its recommendation adopted by the Council, as will presently be announced.

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[1] Published in Quart. Journ. Micr. Sci. XXIV (N. S.), 549.

REPORT OF CHARLES W. SCUDDER, TREASURER.

ANNUAL STATEMENT OF RECEIPTS AND EXPENDITURES, MAY 1, 1884.

May 1, 1883, to May 1, 1884.	
Admission Fees	$65.00
Annual Assessments	1,160.00
Dividends and Income from General Fund	3,670.54
Walker Fund Income	2,704.80
Walker Prize Fund Income	272.00
Walker Grand Prize Fund Income	109.80
Courtis Fund Income	467.50
Bulfinch St. Estate Fund Income	1612.00
S. P. Pratt Fund Income	641.00
Huntington Frothingham Wolcott Fund Income	518.88
Entomological Fund Income	22.50
Laboratory, Boston University and Students' Fees	2,711.75
Balance	450.19
	$14,405.96

May 1, 1883, to May 1, 1884.		
Museum		822.57
Library		686.88
Publication and Printing	1,697.87	
Less Receipts on this account	558.64	1,139.23
Salaries and Wages		6,750.00
Repairs of Building		478.16
Fuel		325.25
Gas		43.38
General Expenses		1,028.46
Laboratory		2,982.03
Paid First and Second Walker Prizes		150.00
		$14,405.96
Excess of Expenditures, over Receipts		450.19

Teachers' School of Science.

Balance due from last year	16.07
Donations from Augustus Lowell, Trustee	1,424.00
	$1,440.07

Teachers' School of Science.

Expended for Lectures, etc	$1,387.87
Balance on hand	52.20
	$1,440.07

BOSTON, MAY 1, 1884.

CHAS. W. SCUDDER,
Treasurer.

The Committee to audit the Treasurer's accounts, Messrs. R. C. Greenleaf and S. Wells, reported the same correctly cast and properly vouched.

The three annual reports were then accepted.

The Secretary read the following report of the Committee to whom the award of the Grand Walker Prize was referred, and announced the action of the Council in adopting the recommendation of the report and awarding the prize — $1,000 — to Prof. James Hall of Albany.

To the Council of the Boston Natural History Society:

The undersigned, designated as a Committee for suggesting the most suitable person to whom may be awarded, at this time, the Grand Honorary Prize instituted by Dr. Walker, "for such investigation or discovery as may seem to deserve it, provided such investigation or discovery shall have been made known or published in the United States at least one year previous to the time of award," after due consideration of the subject, have unanimously concluded to recommend for this prize — Professor JAMES HALL of Albany.

As the founder would appear to have contemplated some particular or integral "investigation or discovery," we need not take into account Professor Hall's numerous works or publications upon North American Geology and Palæontology for the last forty years and more[1], except as they relate to a special time of investigation which Professor Hall early made his own, in which he has long been eminent, and which he may be said to have essentially completed, although a considerable portion of the results, which have been from time to time "made known" to the scientific world, are not yet published *in extenso*, with the illustrations prepared for the purpose.

It is, then, especially for Professor Hall's investigations in North American Palæontology, notably the palæontology of the State of New York and the regions adjacent, and of the earlier geological formations that we suggest this award.

In this field Professor Hall holds a position like that which has been so long occupied in Europe by M. Barrande. If his actual publications are as yet less extensive than those which have made the name of Barrande illustrious, this has not been from lack of material, still less from lack of industry and scientific acumen on Professor Hall's part, but because he has not enjoyed the advantages of independent fortune and magnificent patronage. Giving due credit to the State of New York for what it has done to further the publications of researches prosecuted in its service, it still appears that his prolonged labors have been carried on under many discouragements and with insufficient means.

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[1] Comprised in about twenty-six volumes or parts of volumes and in over two hundred articles or papers, reports, etc.

It is understood, however, that deficiencies in this respect are about to be remedied; and it is hoped that this veteran palæontologist may have the satisfaction of superintending the full publication and proper illustration of his completed investigations.

In recognition of the great value of the scientific work to which Professor Hall's life has been so untiringly and successfully devoted, in encouragement of his closing labors and in testimony of the Society's high appreciation of these services to science, your committee would recommend that the maximum of the prize be awarded upon this occasion.

[Signed] Asa Gray,
J. S. Newberry,
Spencer F. Baird.

March 21, 1884.

Mr. F. W. Putnam for the Committee on the annual Walker Prizes reported that the Committee recommended that a first prize should be awarded to the author of an essay on Lunatia heros.

The envelope containing the author's name was opened and Mr. Albert H. Tuttle of the Harvard Medical School was announced to be the successful competitor for the prize of 1884. The report of the Committee was accepted.

The Society proceeded to ballot for Officers for the new year. Messrs. Kingsley and Blake were requested to collect and count the ballots, and they announced the election of the following

OFFICERS FOR 1884–5.

PRESIDENT,

SAMUEL H. SCUDDER.

VICE-PRESIDENTS,

JOHN CUMMINGS, F. W. PUTNAM.

CURATOR,

ALPHEUS HYATT.

HONORARY SECRETARY,

S. L. ABBOT, M. D.

SECRETARY,

EDWARD BURGESS.

TREASURER,

CHARLES W. SCUDDER.

LIBRARIAN,

EDWARD BURGESS.

COUNCILLORS,

J. A. ALLEN,
HENRY P. BOWDITCH, M. D.,
SAMUEL CABOT, M. D.,
W. G. FARLOW, M. D.,
SAMUEL GARMAN,
GEORGE L. GOODALE, M. D.,
H. A. HAGEN, M. D.,
HENRY W. HAYNES,
B. JOY JEFFRIES, M. D.,
AUGUSTUS LOWELL,
THEODORE LYMAN,
CHARLES S. MINOT,
EDWARD S. MORSE,
WILLIAM H. NILES,
R. H. RICHARDS,
N. S. SHALER,
CHARLES J. SPRAGUE,
M. E. WADSWORTH,
SAMUEL WELLS,
WILLIAM F. WHITNEY, M. D.

MEMBERS OF THE COUNCIL, EX-OFFICIO,

Ex-President, THOMAS T. BOUVÉ,
Ex-Vice-President, RICHARD C. GREENLEAF,
Ex-Vice-President, D. HUMPHREYS STORER, M. D.

Miss C. G. Soule and Messrs. J. C. Branner, C. L. Burlingham and G. L. Chandler were elected Associate Members.

Mr. F. W. Putnam occupied the rest of the evening with an interesting account of discoveries by Dr. Metz and himself in mounds of the Little Miami Valley. He also showed a portion of a human jaw-bone discovered by Dr. Abbott in the Trenton gravel; and human footprints in tufa in Nicaragua found sixteen feet from the surface under several strata of tufa and sands by Dr. Earl Flint.

The following papers were read by title:

THE THEORIES OF ORE DEPOSITS.

BY M. E. WADSWORTH.

The recent publication of the interesting chapter of Professor Sandberger's work relating to mineral veins, in the Engineering and Mining Journal (Vol. XXXVII, pp. 186, 198, 218, 219, 232, 233) has served to call renewed attention, on the part of American mining men, to the theories of ore deposits. The theory of lateral secretion (infiltration, segregation, and impregnation) so strongly advocated by Sandberger is very old, and has been a favorite one among American writers on the subject of mineral veins, appearing even in the older text books, like Whitney's Metallic Wealth of the United States, 1854, pp. 62–68, and Dana's Manual of Geology, 1863, pp. 712–714. This theory appears to have a direct connection with many other forms of ore deposits, besides true fissure veins, and to follow from a universal law, intimately interwoven with the history of the rocks of this globe. It is proposed here to point out this law and its relation to ore deposits, and to call attention to the uncertainty of conclusions drawn from the analysis of the wall rock and its contained minerals. In order to do this, it is necessary to present a brief but comprehensive view of the entire field.

Without entering at all upon the question of the source of those rocks which have come from below the earth's surface, which are known as eruptives, and which form a large portion of the so-called metamorphic series, it is sufficient for the present purpose to state that when they reach the exterior of the earth, their condition is one not adapted to the circumstances in which they are hereafter to exist. For a time, at least, prior to their eruption they have been placed in far different conditions from the atmospheric ones on the earth's surface; and, of necessity, there will be a constant tendency on their part to conform to these changed conditions. This is manifested most conspicuously in their loss of heat, and their passage from a liquid to a solid condition. When solid, it may be said that these rocks are in an unstable condition, in respect to their temperature, and also to the chemical combinations formed on solidification. Their chemical arrangements, as manifested in their constituent glass and minerals, are such as to necessitate a transference to a condition in which they are less acted upon by the agencies to which they are exposed, on the earth's surface and this leads to a degradation, dissipation, and loss of energy on their part. In other words, the rocks tend to pass from an unstable towards a more stable state. The rapidity of these changes depends not only upon their chemical constitution, but also upon the special circumstances in which the rocks are placed. In the basic rocks, or those containing much iron, magnesium, calcium, aluminum, etc., the alterations are comparatively rapid, but in the acidic rocks much slower. If rocks of eruptive origin are studied under the microscope these alterations can be readily traced from their beginnings to the extreme changes, which are usually found to be proportional to their age or some special condition.

It is these alterations which have led to the multiplicity of rock names, and to the confusion of nomenclature; lithologists and geologists generally proceeding on the supposition that as a rock now is, so it always was and always will be. For example, the lava flows of Keweenaw Point, which were once identical with the modern basaltic lavas of Mt. Etna and Kilauea, are now designated, on account of their alteration and age, as melaphyrs, diabases, diorites, etc.; andesite in its changed guise is designated as propylite, diabase porphyrite, porphyrite, diorite, etc.; rhyolite as felsite, quartz porphyry, petrosilex, orthofelsite, etc.; peridotites or olivine rocks, as serpentine, talc schist, etc.

The propylite of the Comstock Lode is a striking example. The present writer was the first to call attention to the fact that the fortieth parallel propylites were altered forms of pre-tertiary and tertiary andesites.[1] The position then taken has been fully confirmed by Dr. G. F. Becker[2], who unjustly appropriates to himself the credit of this discovery, and is supported in this appropriation by his colleague, Arnold Hague.

Dr. Becker further states that every rock in the district has been taken for propylite when decomposed.

The above mentioned changes or alterations in rocks of the same composition appear to be largely dependent upon the action of infiltrating waters, and their rapidity seems proportionate to the temperature. These alterations appear to consist in general, of molecular transferences or chemical reactions in the rock mass as a whole, and are not confined to special minerals; hence has resulted the failure of theories of mineral pseudomorphism to explain *rock* metamorphism or alteration—the pseudomorphic changes in the rock mass being but the resulting accident of the greater and more general metamorphosis. In the process of alteration the origina glass of the rock is broken up, forming various minerals according to its composition, while the original crystallized minerals are changed to a greater or less degree; the whole resulting in the formation of quartz, various ores, anhydrous and hydrous silicates, carbonates, etc. In the course of these changes there is everywhere seen a tendency to localize these secondary products, especially the ores, which results in the removal of material of one kind and the deposition of another in its place, or in the filling of fissures and cavities in the rock. It is not uncommon to find minute veins in rocks, which, under the microscope, show variation in their filling material as they pass through different minerals. That which has now been described as taking place in one rock takes place in all, and frequently with various interchanges and reactions between the different associated rocks. If instead of minute fissures to be filled and the alterations to be observed under the microscope, we gradually pass to deposits visible to the unaided eye, and to the joint or fissure planes affecting large masses of rock, to cavities or to any condition of rock structure that will admit of deposition of mineral matter, then whether we have ore deposits or not seems to depend upon the activity of the alteration and upon the amount and kind of matter stored. It is well known that valuable ore deposits are more apt to occur in regions of

[1] Bull. Mus. Comp. Zool., 1879, Vol. v, 281, 285, 286.

[2] Geology of the Comstock Lode and Washoe Districts. 1882, pp. 12-150.

eruptive and altered rocks. From what has been said the general alteration of rock masses, and the partial localization of their contained mineral matter by percolating waters, would appear to give rise to a large proportion of the ore deposits found in veins, segregations, and impregnations.

Instead of the mineral matter taken up by the percolating waters being deposited in the rock again or in contiguous cavities, it may be borne far away, appearing in spring, river, lake, and ocean waters, and in deposits laid down by them, precipitation taking place wherever the proper conditions exist.

If we start, as all geologists do, with the belief in an originally hot fluid globe, all rocks must have been derived, primarily, from fluid material. The detrital rocks would naturally partake of the characters and changes of the rocks from which their material came; while in the chemically and organically formed rocks there can be readily suggested, in accordance with their special conditions of formation, agencies for the precipitation of useful ores throughout their mass,—the precipitated ores being gathered up subsequently by the percolating waters.

In order to draw any conclusions concerning the reliability of deductions regarding the source of the ore, based on the analysis of the minerals in the country rock, adjacent to an ore deposit, it is necessary to look into the question of the origin of these minerals. It has been found, that if the point of consolidation of rocks be taken as the reference point, their minerals naturally fall into three classes: 1. Those of prior origin—foreign. 2. Those produced by solidification (crystallization)—indigenous. 3. Those produced later by alterations in the rock mass, or by infiltration—alteration or secondary.[1] The first class can be conveniently separated into two divisions:

1. The minerals that are characteristic of the rock whatever may be its locality or age.

2. Those that are accidental, as for instance, fragments caught up during the passage through or over another rock.

Any rock may have in it all three classes or only one or two as the case may be. A few minerals may be cited in illustration: olivine, in the peridotites is an indigenous mineral, but in the basalts is foreign, although generally characteristic of them. Serpentine, when not an infiltration or veinstone product, is always a secondary or alteration one. Hornblende in the recent andesites is foreign, but in the older forms, and in almost all the older rocks of every kind, it is either a secondary product or is a more or less altered mineral. The micas, feldspars and quartz occur as foreign, indigenous and secondary products. As a rule in the modern rhyolites quartz is foreign, but in the older rocks of this type — felsites and quartz porphyries—it is both foreign and secondary. All hydrous oxides and silicates and all carbonates appear to be alteration products.

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[1] Bull. Mus. Comp. Zool., 1879, v, 277, 278.

As a rule the different modes of occurrence of these minerals can be readily distinguished from one another under the microscope by their characters and their relations to the rock mass.

Further, it may be pointed out that olivine, except in the more recent rocks, is found, as a rule, to be more or less altered to, or replaced by, serpentine, quartz, iron ore, carbonates, etc. ; augite by hornblende, biotite, chlorite, etc. ; and feldspar by quartz, kaolin, micaceous and chloritic minerals, etc.

These changes are so common that it is rare to find original minerals in the older rocks that remain unchanged.

Again, almost every mineral in rocks is found to contain inclusions of other minerals, glass, liquids, and gases, thus vitiating conclusions drawn from the chemical analysis of the mineral.

Since ore deposits are, in general, associated with altered or metamorphosed rocks, and occur in regions in which thermal waters have been active, the country rock would naturally be more or less changed, and sometimes completely decomposed. In the process of the formation of the ore deposit, it may happen that the ore material will be entirely removed from the adjacent rock, or this rock may have deposited in it ores which never existed there before ; or again, the ore material may have been brought from a distance by the percolating waters.

From the above it follows that chemical analyses alone, either of the country rock or of its inclosed minerals, lead to unreliable conclusions as to the source of the ores ; and hence it is an unphilosophical procedure to build any general theory upon such analyses.

If, by chemical analysis, any accurate deductions are to be drawn regarding the original source of the ores it seems necessary that we should select those rocks and minerals that are known to be fresh, unaltered, and free from any foreign inclusions that would influence the result. Such materials could only be obtained from recent lava flows, recently formed limestones, etc., for no rock that has been exposed for a considerable length of time to the earth's meteoric agencies can, in the writer's opinion, be said to be in its pristine condition. Most analyses of such rocks have dealt too little in tests for minute quantities of such materials as comprise the more valuable ore deposits, to permit as yet any general conclusion to be drawn. The nearest approach we have to such analyses is in the meteorites, which are unaltered and which in composition and structure are closely allied to certain classes of terrestrial basic rocks.[1] These meteorites are found to contain copper, tin, nickel, cobalt, arsenic, zinc, manganese, chromium, and graphite.

While it would appear probable that the elements of the useful ores were often originally disseminated through the rocks with which they are associated and subsequently concentrated, by the agency of percolating waters, proofs that this theory is correct are yet wanting, the theory resting mainly on the observed structure of the ore deposits, their association and the alteration of the adjacent rocks.

Of all theories that have been proposed to account for ore deposits, there are few, which are not correct for some form of ore deposits in certain localities, while the practical use of these theories is to aid us in understanding the nature of the deposits, as a guide in their exploitation. The difficulty in the use of these theories lies in their abuse, through their indiscriminate application to all deposits. Our rule ought to be to study every deposit thoroughly, and after that study, not before, apply that theory which best answers to the observed conditions, since all theories ought to be generalizations or expositions of observed facts, with a prophecy for the future.

It is not doubted here that all ore deposits, not of a mechanical or eruptive origin, can be attributed to the general alteration and change in rocks, resulting from the general dissipation and degradation of the potential energy of the constituents of the earth's crust, in the universal passage of matter from an active state towards a passive and inert condition.

This general alteration manifests itself in a universal chemical or molecular transference — a transference of material, leading to the segregation or localization of the ores in the places in which they are now found ; it manifests itself in the deposition of mineral matter in the veins and cavities of the rocks themselves, in deposits from springs, in bogs, lakes, etc. From this it would follow that all ore deposits, not eruptive, are superficial phenomena as regards the earth, and dependent on its external agencies ; although they may be deep enough so far as man is concerned. Again, few of these ore deposits would be expected except in regions in which percolating waters and their resulting metamorphism have been efficient agents ;[1] while the various forms of ore deposits would be expected to be associated with, and grade into, one another.

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[1] Science, 1883, I, 127–130.

APPENDIX.

It has been thought that the writer's meaning in the above paper would be better understood, if some illustrations were added to show how the principles employed have been varied by him to accord with the special conditions observed in different localities.

Heidelberg, Feb. 14, 1885.

COPPER DEPOSITS.

In the famous districts of *Portage Lake* and *Keweenaw Point*, south of Lake Superior, the rocks consist of a mixed series of old basaltic lava flows and conglomerates traversed in part by fissure veins.

Locally the conditions in which the native copper is found in these districts give rise to four forms of deposits, known as :

1. *Amygdaloid Mines* in which some of the thinner lava flows (melaphyrs) are worked, the copper being distributed through them in an irregular manner.
2. *Ash-bed Mines* which are in reality the same as the *Amygdaloid* but in the "Ash-bed" the melaphyr is of a more irregular, open, and scoriaceous character.
3. *Conglomerate Mines* in which old sea-beach conglomerates are mined.
4. *Vein Mines* in which true fissure veins are worked.

All these deposits seem to the writer to have been produced by one cause—the action of percolating waters (whether thermal or not) in collecting the copper disseminated through the old basaltic lavas and concentrating it in whatever suitable receptacles existed in the lavas and their associated conglomerates, and in the fissures traversing them. Here the theory of "Lateral secretion" applies, not only to the copper, but to its associated gangue and amygdaloidal minerals.[1]

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[1] Whitney. Contributions to American Geology, 1880, Vol. I. The Auriferous Gravels of the Sierra Nevada of California. pp. 310, 331, 350, 356.

At *Cape D'Or*, on the Bay of Fundy, native copper occurs in relations similar to those observed on Lake Superior. Here, however, are found only the basaltic rocks (melaphyrs and diabases), and the copper is disseminated in part through them, and in part occurs in veins. As at Lake Superior the rocks are more or less amygdaloidal, and the preceding explanation is used here to account for the origin and concentration of the copper; which, however, has not been found at Cape D'Or in sufficient amounts to warrant exploitation.

The copper ores of *Newfoundland*, in the vicinity of Notre Dame Bay, are chiefly the yellow sulphide (chalcopyrite) associated with pyrite and quartz. These ores occur in connection with argillaceous and chloritic schists cut through by dikes and irregular masses of old basaltic rocks (melaphyrs and diabases), in all of which the ores are either disseminated or form gash veins. The theory of their origin adopted by the writer is as follows. During the eruptive activity, but after the principal portion of the basalt, if not all, had been extraversated, the action of percolating thermal waters on the eruptive rock and its adjacent fissured and broken sedimentary rocks led to the concentration and deposition of the copper ore, iron pyrites, and quartz in the places in which they are now found. As in the preceding cases the copper is supposed to have been brought up from the earth's interior by the basalt, at which time the ore was finely disseminated through the lava[2], and subsequently concentrated.

Copper ore occurs on *Waugh's River* in Nova Scotia about three miles from Tatamagouche Harbor, an inlet on the south side of Northumberland Strait. The country rock is a sandstone composed of granitic detritus, and contains clay, fragments of lignite, and other carbonaceous materials. Associated with this sandstone are intercalated beds of red shale, some of which is of so fine a quality that it has been used as a mineral paint. All these rocks dip N. 20° E. 26°. The ore is in nodules and lenticular masses composed of chalcocite or its hydrous carbonate (malachite) scattered through the beds of sandstone and shale. It is so associated with the carbonaceous materials in the rocks, that it is believed that the copper was collected by the percolating waters, precipitated and reduced by the organic matter, and thus collected into the masses found at present, many of which are now in part lignite and in part chalcocite. The change to the carbonate is, of course, a still further change, wrought through the medium of the percolating waters.[1]

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[1] Bull. Mus. Comp. Zool., 1880, VII, 76–157; Proc. Bost. Soc. Nat. Hist. 1880, XXI, 91–103.

[2] Am. Journ. Sci., 1884, XXVIII, 94–104.

ZINC.

During the mining excitement in Maine, in 1879–82, a mine was opened in the town of *Castine*, *Hancock County*, known as the Hercules. The country rock is a fine grained mica schist, much indurated and quartzose. In places it approaches, in character, quartz schist, and in others, a gneiss. The rock contains, in places, abundant pyrites. The dip and strike are variable, the former varying from south to 30° or 40° west, with an inclination of 75° to 81°. The country rock is traversed by small quartzose veins, carrying pyrite and sometimes sphalerite and it is more or less broken and jointed, part of the jointing being parallel to the foliation. When the jointings cross one another obliquely and also when parallel, if sufficiently close together, so that the rock has been crushed or finely divided, the percolating waters have deposited in the interstices more or less zinc-blende, iron pyrites, galena, tremolite and quartz, which in part replace the rock material. This segregating action of percolating waters thus gave rise to the local aggregations of mineral matter in the form of impregnations of the country rock, and of segregated veins. So far as the writer can learn, the above deposit is a fair sample of the majority of those heretofore worked in Maine.

GOLD.

Another of the Maine mines was on *Seward's Island*, town of

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[1] Gesner's Remarks on the Geology and Mineralogy of Nova Scotia, pp. 139, 140; Am. Journ. Sci. 1828 (1), xv, 151–153; Trans. Am. Acad., 1831 (2), I, 289–292; Dawson's Acadian Geology, third editon, pp. 345, 346; Report of the Department of Mines of Nova Scotia, 1876, p. 63; 1877, pp. 48, 49; 1879, p. 13; 1880, pp. 75–77.

Sullivan, Hancock County. Here a fine grained argillaceous mica schist was cut by a diabase dike some forty feet in thickness, intruded approximately parallel to the bedding. Numerous segregated quartz veins cross this diabase and are locally limited to it. The quartz contains calcite, tremolite, chlorite, tetradymite and gold. The geological history appears to be, first, the formation of the sedimentary country rock, secondly, the intrusion of the diabase, and thirdly, the concentration (mainly from the diabase mass) of the vein materials, including the gold.[1]

MANGANESE.

At different times in past years, considerable work has been done in New Brunswick on a manganese deposit at a fall of the *Tete-a-gouche River*, a few miles from *Bathurst*, on the southern shore of the Bay Chaleur. The country rock is a reddish, fine grained argillite, much fissured and broken. The manganese ore (pyrolusite, wad, etc.) has been infiltrated along the fissures, apparently passing from above downwards, and making small irregular gash veins and pockets, the richest portion being in the upper part of the rock.

Another deposit of manganese has been worked at a locality four or five miles southeast of *Truro, Nova Scotia.* The country rock is a sandstone and shaly schist, quite indurated, folded and faulted. As before, the manganese ore is found deposited in fissures and pockets in the rock, and is infiltrated from above. This deposit, like that at Bathurst, is found on the side of a stream, to which, when cutting its bed, the formation of the deposit is probably due. In such cases as these, the theory of lateral secretion has no bearing, according to the writer's judgment.

IRON ORES.

The writer has given sufficient reasons in previous papers why he, in common with some others, can not regard the iron ores of the *Marquette District* of *Lake Superior* as coming either under the head of a deposit by lateral secretion or by sedimentation; but holds that they are for the most part of eruptive origin. Those who have opposed this view have in general based their conclusions on theoretical grounds and not on the actual mode of occurrence of the ores themselves. That the ores have been subjected to mechanical and chemical action since the time of eruption appears clear. This action has not only given rise to subordinate mechanical deposits and to impregnations, segregations, and minor veins, but has also been the means of the molecular rearrangement of much if not the whole of the ore.[1]

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[1] Bull. Mus. Comp. Zoöl., 1880, VII, 181.

The iron ore of *Cumberland*, *Rhode Island*, has been shown by the writer not to be a simple ore, but a rock composed chiefly of titaniferous magnetite, feldspar and olivine. This ore appears to be of an eruptive origin.[2]

The iron ore (magnetite) of *Port Henry* (Cheever Ore Bed) is associated with and lies in a peculiar gneissoid rock composed prinpally of a clear, glassy, triclinic feldspar. This ore partakes of the flexures of the gneiss and is in all respects to be regarded as a sedimentary deposit; but whether it is to be regarded as a chemical precipitate or a detrital accumulation the writer has at present no opinion. The ore at times ramifies through the gneiss in a way that only a chemical deposit or eruptive mass could, but otherwise it has none of the characters of an eruptive. This ramification then belongs to, or is the result of, chemical action, yet it probably is not original, but a secondary result of chemical agencies since deposition. Evidences of such action are commonly seen in the limestones in the vicinity, while its exciting cause may have been the eruptive rocks (gabbros, etc.) which are quite abundant in the vicinity.

The ores in this part of the Lake Champlain region have been cited as proofs by analogy that the Lake Superior iron ores were also sedimentary deposits, but such arguments are deceptive, since the deposits in the two districts in question have nothing in common in their structure, their relations to the associated rocks, or in their apparent origin, beyond the fact that both are magnetite and both are associated with old crystalline rocks.

In the vicinity of *Bathurst* boulders of iron ore (hematite and jasper) were found in the bed of the *Tete-a-gouche River* which closely resemble the associated hematite and jaspilite of the Marquette District, Lake Superior.

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[1] Bull. Mus. Comp. Zoöl., 1880, VII, 28-36, 66-76, 494, 495.—Proc. Bost. Soc. Nat. History, 1880, XX, 470-479.

[2] Bull. Mus. Comp. Zoöl., 1881. VII, 183-187.—Proc. Bost. Soc. Nat. Hist., 1881, XXI, 195-197.—Lithological Studies, 1884, pp. 75-81.

The origin of these boulders, or rather of similar ores, was found to be as follows: near the Peters River, diabase dikes had cut through the red argillite (see above, under manganese) indurating it and filling it more or less with iron ore. This argillite when broken away and water-worn gave rise to the deceptive boulders mentioned above, which had thus an origin entirely different from the Lake Superior ore.

ON A SUPPOSED FOSSIL FROM THE COPPER-BEARING ROCKS OF LAKE SUPERIOR.

BY M. E. WADSWORTH.

My attention was called by my friend, Professor Hyatt, to this specimen, which he had seen in the collection of Professor James Hall, of Albany. On my application Professor Hall very kindly sent it to me, and permitted all necessary work to be done on the specimen that could be accomplished without injuring its value.

The great interest attaching to this form is owing to the disputed age of the copper-bearing rocks and to its resemblance to a fossil, a resemblance which is so great, that so far as I am aware, every palæontologist, who has seen the specimen, has taken it for an organic body. That this resemblance is close, is shown by the fact that even the eminent palæontologists just mentioned have regarded it as a fossil.

Instead, however, of being of organic origin, it appears to have been formed by the flowing of a pasty lava in such a manner as to raise a series of ridges, giving the surface an appearance closely like that of some cephalopods. This lava flow, which evidently was once a basaltic lava, like that of Mt. Etna, or of the Sandwich Islands, has since undergone certain changes which have altered its interior structure and composition. As is the case with all lavas, the structure is more crystalline in the interior, and more compact on the surface. At the present time the dark reddish brown rock is one that would be denominated, by most lithologists, a melaphyr. Much crystallized calcite occurs in the specimen, having the same characters as have nearly all of the secondary calcite in the Lake Superior traps. If the surface of the apparent fossil be examined, the lava flow is seen to be covered by a hard reddish deposit, probably arising from the decomposition of the surface of the crust. Beneath this coating appears the dark reddish brown compact rock, containing green delessite and white calcite. On a polished surface this portion is found to extend, with a gradually increasing coarseness of crystallization, and greater alteration, until the rock mass proper, or matrix of the fossil, is reached. A thin section taken of a portion of the melaphyr in the body of the fossil, and therefore, properly of the fossil itself, has a grayish-brown groundmass inclosing crystals of feldspar, altered olivine grains, and amygdules of calcite and delessite. The feldspars are much altered, but most show in polarized light that they are triclinic. The olivine has black borders with orange yellow interior portions. The groundmass is much altered and is composed largely of fibrous material and dark granules.

The form has a terminal point resembling a filled canal which adds to the deceptive appearance. This was found, however, to be a little nodule of melaphyr cemented to the rock mass by the water-deposited calcite.

Among the reasons for regarding this form as a simulative lava flow, and not a fossil, are the following: the macroscopical and microscopical characters of the rock mass are identical with those of the melaphyrs of Keweenaw Point, which have been proved to be old lava flows. The matrix of the fossil, and the fossil itself, are lithologically the same, while they form the same continuous mass ; the fossil itself being a portion of a melaphyr, an old basaltic lava, has a constitution inconsistent with its supposed organic nature ; the form itself is too irregular in its outline for an organic body ; and the apparent nib is a nodule of melaphyr, and not material filling a canal.

Professor Hall, regarding the form as a fossil, very kindly wrote me a note, the following extracts from which I insert in accordance with my promise to him and also to give evidence that the form closely resembles a fossil : "The enclosed body I regard as a fossil, and I know of nothing except the Huronia or siphuncles of Orthoceratites with which it can be compared. See Barrande's Sil. Syst. Bohemia, Vol. II, plates 231,232, 433–437.[1]

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[1] Also Foster and Whitney's Report on the Lake Superior District.

"The greater part of these Huronias, so-called, are of Niagara age, but the nummulated siphuncles are more marked in the Orthoceratites of the older rocks."

After receiving the above letter with the specimen, the examination of the latter convinced me that it was a lava flow simulating an organic structure, which similitude had been increased by the alteration the rocks had undergone when *in situ.*

The reasons for regarding it as a portion of a lava flow were presented to Professor Hyatt who at that time considered it a fossil. He assented to the correctness of my views when the evidence was pointed out on the form itself; and also very kindly consented to write a statement for publication, giving his present views both for and against its organic nature, as follows:—

"The first impression of the rock specimen from Copper Harbor or Eagle River led me to consider it the much altered remains of a denuded specimen of the Endoceratidæ. Description can convey no adequate expression of the closeness of this superficial resemblance; it should be figured. The aspect is that of an Endoceras, the chambers of which have been completely filled with the matrix, the siphon calcified and the terminal point of a sheath projecting out of the calcite. This sheath having been, as is common in Endoceras, filled by the matrix, is represented at this terminal point by a nib of the original red rock rising in the centre of the calcite. Both the apparent chambers and the siphon have been worn away or denuded and the remnant covered by the existing matrix. The specimen as it now stands is only partially uncovered exposing part of nine chambers on the left of siphon and an arc above with surface continuous to the right side. On the left the outer part of three chambers is exposed. In the centre of the arc above rises the projecting nib of the apparent sheath and a mass of surrounding calcite.

"On the left side one sees the nine chambers nearly as in front, apparently fading into the original matrix. On the right side portions of the three chambers visible from the front and two more, come into view, the remaining portions corresponding to those on the left being apparently broken away. On the base the outlines are too faint to be distinctly traceable, but either the arc differs in contour decidedly from what it is above or else it is not continuous. I incline to the opinion that it differs greatly in contour. The fact that this is a worn specimen and that the matrix does not appear to be distinct from the filling of the supposed chambers of the fossil would naturally excite suspicion, but could not be considered conclusive unless demonstrated microscopically. The differences of contour between the lower and upper exposures, however, are fatal to the supposition that it is an Endoceras, or any other known form of chambered cephalopod. Considerable irregularity in the width of the chambers does occur in some specimens of Endoceras, but hardly so strongly expressed as in the folds on the left of this fragment. It would strike one well acquainted with the Endoceratidæ also that the chambers have reversed curvatures, that is they are convex instead of concave, an unheard-of modification among the Nautiloidea.

"You have already pointed out the essential lithological characteristics of the example under consideration, and it is probably owing to this fact that I also notice on the left side a return contour which looks like the beginning of a third fold.

"Paleontologists are not apt to expect such close pseudomorphs of fossils. This and other examples like one also now in Professor Hall's possession, and a much closer copy of a Cyrtoceras or Nautilus than this of an Endoceras, should be published as carefully as if they had been real fossils. They could be made quite useful in the shape of cautionary signals, and would prevent many mistakes. The facts noted by you, I have also seen and verified to the extent my knowledge permitted, and the accidental separation of the red nib of the apparent sheath, and the aspect of the exposed surface of the calcite, settle the question against any attempt to consider it as the terminal point of a true sheath."

The specimen was received from Mr. James T. Hodge, some twenty-five or thirty years ago by Professor Hall, but he is in doubt whether it is from Eagle River, or Copper Harbor. Prof. J. D. Whitney, however, remembers a similar form, found at Copper Harbor about 1850, hence, it is probable that this is from the same locality. Professor Hall states that it remained in his possession unnoticed so long because he not only hoped to visit the region, but also because he hoped that other specimens would be found.

In order that no one may think that the present writer is unduly anxious to place this form in the mineral kingdom, it may be pointed out that no one conversant with the discussions relating to the age of the copper-bearing rocks, can for an instant doubt that it would afford the writer the greatest pleasure if an authentic Palæozoic or Mesozoic fossil could be found in them.

The object of this article is to call attention to this pseudofossil, which may serve to aid in preventing, in the future, the too ready acceptance of simulative forms for genuine fossils, of which the history of geology presents many disastrous examples, among which the Eozoön Canadense stands preëminent.

General Meeting, May 21, 1884.

Dr. B. Joy Jeffries in the chair.

The following letter was read:

New York State Museum of Natural History,
Albany, May 10, 1884.

Mr. Edward Burgess, Secretary.

Dear Sir:

I have received your favor of the eighth instant, announcing to me the distinguished honor that the Council of the Boston Society of Natural History has awarded to me the Grand Walker Prize as a recognition of my services in the cause of American palæontology, and enclosing to me, at the same time, a copy of the report of the committee.

I was certainly surprised to learn of the action of the committee and of the council, for I had never expected that my name would be considered in the award of this Grand Prize.

I feel that, under other circumstances, I might have done work worthy of such a recognition, but mine has been carried on amid so many difficulties and with so many long interruptions to break the continuity of thought and plan, that I feel the result will not be what it ought to be and far below what I had aimed to accomplish. But more than once, after such interruptions, the appeal to my patriotism and my love of science, sustained by my own sanguine hopes, have impelled me to go on with my work. And when, again, after years of comparative inactivity, I have undertaken to complete a work, to which, with the knowledge and experience of years, should be added the vigor of youth for its accomplishment, I sometimes fear that its consummation will be rather an apology for what ought to have been done, than the expression of an achievement. I cannot find language to express to you the great gratification it has given me to receive this mark of the approbation of my services to science by men whom I esteem and honor and who have been my co-laborers for many years.

Coming from your Society, it reminds me of my first feeble efforts to learn something of natural science and of the time when I received help and encouragement from the founders of the Boston Society of Natural History, among whose earlier and later members I have counted many dear friends,—some of whom have passed away and some who still live to do noble work in the cause of science.

It comes to me like a distant, pleasant echo, almost from the home of my childhood and youth, and brings up the recollections of my associations with men and with nature which will ever remain with all the freshness of life's earlier years.

Please present to the Council of the Boston Society of Natural History my warmest thanks for the honor thus conferred upon me, and believe me,

With the most sincere regard,
Very truly yours,
[Signed] JAMES HALL.

Mr. S. Garman spoke of an Indian hiding-place in the heart of the "bad land" of Missouri. A ring of stones, heaped around the edge for protection from the weather, marks the position of each lodge. Mr. Garman also described some Indian burial places of the western coast of South America, illustrating the different aboriginal methods of burial. He thought the varying circumstances of the various tribes had induced the different customs he had noticed, each adapting itself to the accidents of environment.

Professor Hyatt discussed the affinities of Beatricea, a fossil variously regarded as a sponge, a coral, a cephalopod and even a plant. It seemed to him to be probably a foraminifer.

GENERAL MEETING, OCT. 1, 1884.

The President, Mr. S. H. Scudder in the chair.

The President announced the death, during the vacation, of Francis Gregory Sanborn, the well-known entomologist and assistant in the Society's Museum, from 1867–1872.

Mr. S. Garman discussed the classification of sharks and particularly the relationship of the curious form Chlamydoselachus, shown by him to the Society last winter.

Professor A. Hyatt described a new and singular form of Cephalopod, which he called Stereotaeceras, and which was known only by fragments of the huge siphon.

Mr. Scudder alluded to Mr. Forel's recent investigation of the rate of glacial motion in the Alps. Part of the boulder behind Agassiz's station on the Aar glacier was identified this summer and its present position gave the mean annual rate of movement in the median moraine as 55½ metres.

GENERAL MEETING, OCT. 15, 1884.

Mr. S. Garman in the chair.

Prof. A. Hyatt described the statoblasts of Chalinula arbuscula from Annisquam which closely resemble those of Spongilla and whose existence breaks down the distinction between the fresh water and marine sponges based on the supposed presence or absence of statoblasts in these groups.

SECTION OF ENTOMOLOGY, NOV. 25, 1884.

The President, Mr. S. H. Scudder in the chair.

Mr. J. H. Emerton reviewed Kaiserling's Therididae Americanae and the fifth volume of Simon's Arachnées de France, which also includes the Therididae, and discussed the systems of classification of this family proposed by these authors and himself.

Mr. Scudder showed drawings of a carboniferous Telephonus recently discovered at Mazon Creek, while a similar species of the same age was simultaneously found in Europe.

General Meeting, Dec. 3, 1884.

The President, Mr. S. H. Scudder, in the chair.

Dr. E. B. Wilson and Miss Clara Pike were elected Associate Members.

Mr. F. W. Putnam occupied the evening with an account of recent explorations of mounds in Ohio, carried on for the Peabody Museum at Cambridge, by Dr. C. L. Metz and himself.

The particular group which he described is known as the Liberty Works, and is situated on the farm of Mr. Edwin Harness in Liberty township, Ross Co., Ohio. These ancient earthworks were surveyed by Squier and Davis in 1840. Their plan and description are published in their well-known volume on the Ancient Monuments of the Mississippi Valley. With their plan in hand, the earth-walls of the square and great circle can be easily traced in the cultivated fields, on both sides of the Narrow Gauge Railroad. A portion of the earth-walls forming the square are still fairly well preserved in the woods beyond the field. In the next field to the northwest, the outlines of the walls crossing the pike, and connecting the square with the small circle, can also be seen, while the small circle can be followed in the woods on the west side of the pike, toward Mr. Harness's house. Several of the depressions or excavations noted by Squier and Davis about and within the works, are still defined, and the little circle to the east of the square and the long embankment running southward, can still be made out.

Squier and Davis represent five small mounds inside the great square of twenty-seven acres area. These have been levelled by cultivation, but we determined the position of three, one of which we thoroughly examined and found that it was simply a mound of earth thrown up inside one of the "gateways" of the square. Three mounds, one twice the size of the others, are represented on the plan as just outside one of the "gateways" on the eastern side of the great circle of forty acres area. All these have been much reduced in height by ploughing over them, but probably only the superficial portions were disturbed. These three mounds we examined with care and found that the small one to the westward contained simply a small bed of ashes. The other two proved to be burial mounds of considerable interest. The human bones were much decayed. Various objects made of copper, stone, shell and mica, found in these mounds were of the same general character as those of the large mound, and consisted of copper plates, spool-shaped ear ornaments made of copper, a few small ornaments of copper, one small copper celt, a crescent-shaped ornament cut out of slate, and another small stone ornament, a few large beads covered with copper, and a smaller one covered with silver over the copper, like those found in the large mound, also shell beads and other small objects which have not yet been examined. In fact, as everything found during our explorations was immediately packed on the spot, so as to prevent anything from being mislaid, broken, or mixed with objects from another portion of the mound, we shall not know exactly what has been found until the collection is studied in the Museum at Cambridge. When this has been done, they will be described and figured, and a full report of the exploration will be printed.

A larger mound in the cornfield, to the north of the three above mentioned, was also thoroughly explored. In this we found an extensive bed of ashes and charcoal at the bottom of the mound. This ash-bed covered nearly the whole area occupied by the mound, and in it we found many fragments of pottery, and cut pieces of mica, of various shapes. A large piece of grass matting and a mass of burnt seeds, burnt nuts and acorns were found in the ashes. In one place the charred matting was an inch or more in thickness, showing several layers. Near the centre of the mound, and extending to the south, was a long, narrow pit, about 9 × 2 feet, which was a foot in depth. At the bottom of this pit were a number of burned stones and over them ashes and charcoal, fragments of pottery and a few burnt bones. Thus it will be seen that the several mounds connected with the extensive earthwork were erected for different purposes and vary considerably in their structure.

Near the eastern corner of the part of the earthwork which we have called the great square, and within the line of the circular embankment forming the great circle, stands the largest mound of the group and known as the Edwin Harness mound.

This mound proved to be of great interest and of a character unlike any other we have explored. It is 160 feet long, from 80 to 90 feet wide and from 13 to 18 feet high along the central portion, which rises gradually from the southern to the northern part.

About forty feet from the centre, at the northern portion, we discovered the first of the burial chambers, of which we afterwards found a dozen in all. These chambers were made by placing logs, from five to six inches in diameter, on the clay which forms the lowest layer of the mound, in such a way as to make enclosures six to seven feet in length and from two to three in width and about a foot in height. In these the body was placed, evidently wrapped in garments, as indicated by the charred cloth found in several of the chambers. With the bodies were placed various objects, such as copper plates, ear ornaments, beads of shell and copper, and, in one instance, long flint-points. In two instances the skeletons were found extended at full length within the chambers, the outlines of which could be traced by the cast or imprint of the logs in the clay; the logs having decayed, leaving simply a dark dirt. On the breast of one of the skeletons was a copper plate, or ornament of thin copper. The action of the copper had preserved the structure of a finely woven piece of cloth, found between the plate and the bones of the chest. In the other chambers the bodies had been burnt on the spot, as conclusively shown by the relative position of the pieces of burnt bones and the fact that in two instances portions of the body had fallen beyond the fire and escaped burning. It also became evident, as our exploration progressed, that these chambers were covered by little mounds of gravel and clay, and that in those where the burning had taken place, the covering of earth was made before the body was consumed, as shown by the small amount of ashes and the reduction of the logs to charcoal in their position on the clay floor of the chamber, which was burnt to a varying thickness, according to the amount of fuel supplied. We also became convinced that the burials and cremations were not all made at the same time, and that after all these little mounds had been made, earth was brought from different places about and heaped over all. This was then covered with a thin layer of gravel and surrounded by stones, thus forming a large mound as a monument to mark the spot.

It is of interest to note that Squier and Davis, in 1840, dug two pits in this mound. At the bottom of their pit A, which was just south of the centre of the mound, they struck one of these burial chambers. They state that the skeleton was partly burnt and that it was enclosed in a framework of logs. With these burnt bones they found a copper plate and a pipe carved out of stone. They also remark that the body seemed to have been enveloped in matting. Their pit B was about twenty feet to the northwest of the centre, and here they came to another burnt skeleton, as shown by our explorations, although owing to the partial examination only which they made, due to the pit caving in, they thought they had found an "altar" and mention the burnt burial chamber as such. They also state that they found at this place several implements made of bone. At the side of their excavation, we also took out about half a dozen pointed implements made of the leg bones of deer.

During the early part of the present year, several school boys, under the lead of Mr. Wilson, dug two pits in the mound, one of which was between those made by Squier and Davis over forty years ago, and the other at the side of Squier and Davis' pit B. In both of these a remarkable lot of objects were found. So far as "relics" are concerned, the boys made a lucky hit and took out more objects from one of their pits than were found in all the rest of the mound. The larger part of these objects we have been able to secure from the boys and from Daniel Harness, Esq., who very kindly gave to the Peabody Museum all that he had purchased from the boys at the time, realizing that they would be of more importance and value to science if placed in the Archæological Museum with the other objects from the mound, than if held in private hands as mere curiosities. Among the specimens thus obtained were two or three copper celts and copper plates. There were also several spool-shaped ear ornaments made of copper and covered with meteoric iron, in the same way as those from the Turner mound in the Little Miami valley, and also a celt made of meteoric iron. Thus we have an important link connecting the people who built this great mound and the earthworks about it in the Scioto valley with the builders of the singular group on the Turner farm in the Little Miami valley.

General Meeting, December 17, 1884.

The President, Mr. S. H. Scudder in the chair.

Dr. G. L. Goodale discussed the latest views held by botanists as to the molecular structure of cellulose, and the continuity of protoplasm in vegetable tissues.

Mr. S. H. Scudder showed the photograph of the oldest fossil insect yet known, a scorpion discovered in Gotland during the past summer, in Upper Silurian beds, by Dr. Lindström. The fossil differs from modern scorpions in the short, stout, tapering legs, terminated by a single claw.

General Meeting, Jan. 17, 1885.

Professor A. Hyatt in the chair.

The following paper was read:

COLORS OF SOILS.

BY W. O. CROSBY.

The usual colors of soils and of superficial detritus generally,—the various shades of black, gray, green, blue, brown, yellow and red—are well understood, resulting chiefly from the admixture in various proportions of vegetable mould and more coal-like forms of carbon, and of iron in the forms of ferrous salts and the various hydrous and anhydrous oxides. My present purpose, therefore, is not to undertake a general discussion of the colors of soils, but to suggest an explanation of the marked contrast in the colors due to the ferric oxides presented by the soils of high and low latitudes. This general difference in color between northern and southern soils is an unquestionable fact, and must be familiar to many travellers; and yet but few geological writers have even mentioned it, and, so far as I can learn, no explanation of it has heretofore been proposed.

In all latitudes, the most superficial detritus, the true agricultural soil, is, in a large measure, distinctly carbonaceous, or the organic matter has at least been sufficient to more or less completely discharge the brown, yellow and red colors due to the ferric oxides. But in the surface soil to a considerable extent, and in the subsoil generally, the ferric oxides are still the predominant coloring agents. Now, throughout the northern states and Canada the soils, where their colors can be ascribed to ferric oxide, are generally, almost universally, brownish or yellowish, but not distinctly red. The only important exceptions are where the red soil results from the disintegration of a red rock, or is itself geologically old. Thus, the red color of the soil on the triassic areas, and of the clays at Brandon, Vt., and Gay Head, does not belong to the present or any recent period, but is due to the peroxidation of iron in triassic and tertiary times. On the other hand, one of the most striking features of the scenery of the southern states, especially for northern eyes, is the bright red color of the soil and the general predominance of this color over the brownish and yellowish tints. This begins to be noticeable in the latitude of southern Pennsylvania, and becomes more and more marked as we cross Virginia into the Carolinas ; while in the West Indies and South America the redness of the soil is even more intense and universal than in the southern states. So far as I have been able to learn by reading and inquiry, this difference in color between the soils of high and low latitudes is more or less distinctly observable in all longitudes and in the southern as well as the northern hemispheres.

The brown, yellow and buff colors, so characteristic of northern soils, are undoubtedly due chiefly to the yellow ferric hydrates, like göthite, limonite and xanthosiderite ; while the red color of southern soils, although commonly attributed to hematite, is probably in many, if not most, cases due to the red ferric hydrate, turgite. I know of no way to determine whether or not any part of the water which a red clay yields on analysis is combined with the ferric oxide, but it seems necessary to suppose that a part of it is, since the conditions are extremely unfavorable for the formation or existence of ferric anhydride. The main question, then, Why are northern soils yellow and southern soils red? is really equivalent to, Why is the ferric oxide in northern soils highly hydrated (göthite, limonite, etc.) while that in southern soils is only slightly hydrated (turgite) or anhydrous (hematite)?

It is manifestly impossible to answer this question by correlating the difference in color with a difference in the rocks of the two regions ; for, while the red clays of the south are found on nearly all geological formations, they appear to have their best development on the primary or crystalline rocks, and these are indistinguishable from the similar rocks of the north. But a satisfactory solution is, I think, found by correlating the color-difference with the one physical feature upon which all the other contrasts between the north and south depend—the climate. In other words, the difference in color depends upon a difference in temperature. It is well known to chemists that ferric hydrate, the coloring agent of northern soils, is dehydrated at the temperature of boiling water; and it seems probable that a partial, if not complete dehydration may result at much lower temperatures, if unlimited or geologically long time is allowed. And, in this connection, it is important to observe that the surface soils of the south attain at times a high temperature, and that in both regions, but especially in the south, the detritus is quite certainly chiefly of preglacial origin. The detritus of the south, it is well known, is, except on the flood-plains of the rivers, chiefly sedentary, often retaining almost perfectly the structure lines of the rock from which it is derived; while the débris covering the rocks in the north is almost wholly transported, consisting of the modified and unmodified glacial drift. Hence it is evident that the characteristic colors of the north and south are approximately continuous with the sedentary detritus and drift. But it seems impossible to ascribe the color-difference to glaciation; for wherever in the north we find sedentary soils, either post- or anteglacial, as in the case of trap dykes which have been decomposed to a considerable depth below the surface of the enclosing rocks, the colors are brown and yellow, never red.

Although it seems not to have attracted general attention, my observations show that frequently, if not always, the red color of the southern soils is a merely superficial phenomenon, being most strongly marked at the surface and gradually changing to yellow at a moderate depth. This fact, if fully established, will strongly corroborate the view here proposed, that the solar heat is the principal cause of the dehydration of the ferric oxide.

Nearly all soils originate, directly or indirectly, in the decay of the silicate minerals of the crystalline rocks, in which the iron is very largely in the ferrous state. And it is well known that the meteoric waters percolating through the rocks not only introduce the carbon dioxide, which is the chief agent in the kaolinization of the anhydrous silicates, but also the free oxygen required for the peroxidation of the iron. The sedentary soils of the south show very plainly also that the second process does not keep pace with the first; for, while the superficial soil exhibits the brilliant colors of the ferric oxides, in the lower portion, which shades off insensibly into the underlying rocks, grayish and bluish tints prevail, indicating that the iron is still chiefly in the ferrous state. Hence the normal vertical order of colors in sedentary detritus seems to be as follows, beginning at the base: 1, Bluish, grayish and neutral tints due to ferrous oxide; 2, The yellow and brown tints of the ferric hydrates; and, 3, in warm countries, the red resulting from the dehydration of the ferric hydrates. It is interesting to note in this connection, that, as shown by Hitchcock and other students of glacial geology, a similar contrast in colors is presented by the upper and lower divisions of the till or unmodified drift. The lower till, commonly regarded as the ground moraine of the ice-sheet, is usually of a bluish gray color, while a yellowish or buff tint predominates in the upper till, which appears to be made up chiefly of materials which rested upon and in the ice and were gradually deposited as it melted.

Prof. Hitchcock has suggested that the more perfect exposure of the materials of the upper till to the air during the melting of the ice is sufficient to account for the more perfect oxidation of the iron in the upper than in the lower till. This explanation, however, requires that the drift should be mainly, if not wholly, of glacial origin, and is inconsistent with the fact that, during the ages since the glacial epoch, the surface of the upper till, although freely exposed to atmospheric influences, shows no sensible increase in the oxidation of the iron. While, on the other hand, we can hardly doubt that the drift areas were, in preglacial times, covered with a thick sheet of sedentary detritus, the upper and lower portions of which must have differed in color precisely as the upper and lower till do now. These considerations evidently favor the view that the upper and lower divisions of the preglacial detritus were not completely mixed up, or the line between them entirely obliterated, by the ice sheet, but are represented by the upper and lower till. It must be confessed, however, that this view is not easily reconciled with our ordinary conceptions of glacial action, and especially with the striation and scoring of the underlying rocks and the presence in the upper till of numerous angular blocks; and it is offered here merely as a suggestion which may assist in arriving at a correct theory of the upper and lower till.

GENERAL MEETING, JAN. 21, 1885.

The President, Mr. S. H. Scudder, in the chair.

Mr. Percival Lowell read a paper on the characteristic costume of the Coreans, describing the shape, materials, color, origin, etc., of the garments worn by persons of various rank and occupations, showing with the stereopticon a series of photographs in illustration.

Prof. Edw. S. Morse read extracts from his notes on the habits, superstitions, etc., of the Coreans, which he had gathered from talks with a native Corean, at present living in his family.

Mr. Scudder showed a map giving the geographical results of the Greely expedition, obtained from photographs of plottings made by Lieut. Lockwood.

Mr. Scudder also noted the recent discovery of a winged insect from the middle Silurian, which was supposed by Brongniart to be a Blattarian.

GENERAL MEETING, FEB. 4, 1885.

The President, Mr. S. H. Scudder, in the chair.

Mr. Wm. W. Davis read a paper on "Geographic Evolution," illustrated by models for use in teaching.

The main point of the essay was that physical geography should not be limited to the description of topographic forms as they now exist, but should consider as well the past forms from which the present ones have been derived and the future forms into which they will develop. To illustrate the views of this subjeet, a brief statement was made of the evolution of volcanic *mesas* or table-mountains, such as are numerous in Germany along the Rhine and in our far western territories; of the narrow gorges, headed by waterfalls, such as are common in New York; and of the final stage of old plateaus, to which the name of base-level plains was applied. Relief models were exhibited in further explanation of the changes described. A considerable advantage was claimed for this method of instruction over those commonly employed, inasmuch as it invests geography with the interest that is attached to all sciences in which the changes consequent upon progressive development appear, instead of holding it down to the description of actual and apparently ultimate forms.

Mr. T. T. Bouvé made some remarks in the origin of the materials composing the conglomerates of the Boston basin, emphasizing the importance of atmospheric disintegration rather than water action in their production.

GENERAL MEETING, FEB. 18, 1885.

The President, Mr. S. H. Scudder, in the chair.

A memoir on the Palaedictyoptera, by Mr. S. H. Scudder, was presented by title.

The Secretary read the following letter from Mr. W. G. Binney:

TO THE BOSTON SOCIETY OF NATURAL HISTORY:

In accordance with what I believe would be the wishes of my father, the late Dr. Amos Binney, I give absolutely to the Society the Binney Library and the oil portrait of my father, by Harding, deposited by my mother, but now my property under my father's will.

W. G. BINNEY.

The thanks of the Society were voted to Mr. Binney for this valuable gift. The library numbers 975 volumes and a small number of pamphlets, including many rare and important works.[1]

Letters were read from Profs. Ferdinand Cohn of Breslau, Paul Mayer of Naples, F. Fouqué, E. J. Marey and A. M. Lévy of Paris, acknowledging their election as Corresponding Members.

GENERAL MEETING, MARCH 4, 1885.

The President, Mr. S. H. Scudder, in the chair.

Dr. E. G. Gardiner gave some of the results of his paper, recently published by the University of Leipzig, on the development of the epitrichium in birds.

Professor Hyatt made a few remarks on mechanical evolution, referring particularly to his theory of the origin of the notochord and to Cope's explanation of vertebral segmentation.

GENERAL MEETING, MARCH 18, 1885.

Vice President, Mr. F. W. Putnam, in the chair.

Mr. C. E. Ridler read an annotated list of the rarer plants of Kingston, Mass.

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[1] See Proc. Bos. Soc. Nat. Hist., VI, pp. 97–107.

Mr. Ridler also described various stone implements, chiefly from the neighborhood of Kingston, and now in collections of citizens of that place.

General Meeting, April 1, 1885.

The President, Mr. S. H. Scudder, in the chair.

Dr. E. B. Tylor of London and Prof. Adolph Bastian of Berlin were elected Honorary Members. Prof. Carl Semper of Würzburg was elected a Corresponding Member.

Prof. G. F. Wright gave an account of his investigations during last summer upon the southern boundary of the glaciated area, tracing it across Illinois, running a few miles south of Carbondale (where excellent striæ were found upon the bed rock), and reaching the Mississippi River a little above Grand Tower.

General Meeting, April 15, 1885.

Vice President, Mr. F. W. Putnam, in the chair.

Mr. Putnam showed a composite photograph, combining the pictures of seventeen officers of the American Association for the Advancement of Science, made by Mr. W. Curtis Taylor of Philadelphia. This was printed from a negative taken from seventeen photographs, each exposed about five seconds.

Mr. Percival Lowell read a paper on the evil-spirit creed of the Koreans.

Annual Meeting, May 6, 1885.

Vice President, Mr. F. W. Putnam, in the chair.

After the records of the preceding and the last Annual Meeting had been read, the Chairman in fitting words alluded to the death of Dr. Samuel Cabot; speaking of his long connection with the Society and of the extent of his ornithological studies, and announced that his family had expressed their intention to present to the Society the rarer and type specimens from his private collection of birds.

The following reports were presented:

REPORT OF ALPHEUS HYATT, CURATOR.

The Curator has for some years past recognized the need of making a collection which should serve as an explanatory introduction to the Museum of the Society. This collection should stand in the vestibule, where there is ample room for its accommodation, and where it would necessarily first demand the attention of a visitor.

It should consist of three parts or sections, first Statical Geognosy or Physiognosy ; second, Dynamical Geology ; third, Dynamical Biology. The examples should be well selected, comparatively few in number, and so arranged, that a visitor would be able to grasp within a limited time the leading ideas which have governed the arrangement of the whole. In other words, it should be a concentrated and illustrated history of the relations of the earth and its products. The plan is perfectly feasible and some of the materials are already at hand by which it can be effectively begun.

The first section should contain the models of the earth and sun which we already have, and specimens exhibiting the composition of the earth, its mineral, vegetable and animal constituents, and their importance and relations when considered as substances in a state of rest. This first section, therefore, as suggested by Prof. W. O. Crosby, would be most appropriately termed a statical collection in contrast with the succeeding dynamical collections.

The second section, Dynamical Geology, needs hardly any explanation. It should show the results of the action of the various forces, which have moulded the continents and formed the basins of the oceanic areas. The first series of examples would exhibit the action of subterranean forces, or what should be termed the fundamental causes of modification, which have upheaved mountains and depressed the complementary parts of adjoining areas, the results of earthquakes and land slides, faults, volcanoes and so on.

The second series of examples should show the action of the more superficial or secondary agencies, such as the effects of denudation which have destroyed the land by sweeping off of the surface, the carving out of river channels, and the transportation of sediments to the sea, the formation of rock masses by the accumulation of this debris in the sea, the building up of land by animals as in coral reefs, the action of the winds in destroying as well as building up rocks, and other similar topics. It will be noted that in many cases, the complementary action, or results of the action of these forces, will be exhibited in examples of their destructive as well as constructive aspects, placed close together so as to bring out the contrast in an effective manner.

The section of Dynamical Biology should consist also of two subdivisions; first, results of the fundamental or purely physical causes of change, and, second, the secondary or organic causes of change. We have in several essays taken the ground, that the selective action of physical forces, which has heretofore been confounded with natural selection, should be entirely separated from the latter, and called physical selection. This is a primitive law by which animals are modified, and those which are suitable and modifiable are selected, and those which are unsuitable, and incapable of modification, become scarcer and finally disappear.

Natural Selection, as compared with Physical Selection is secondary and is active only when one animal comes in contact with another during the struggle for existence. The modifications produced by one of these agencies are distinct and separable from those produced by the other, and can, we think, be exhibited by means of properly selected examples.

The object of the collection is parallel, and at the same time supplementary to that of dynamical geology. In this last we shall treat of the mode of action of the agencies which have modified the earth's surface and built up its varied contours, while in the biological series, the object in view will be a clear exposition of the mode of action of the agencies which have controlled the evolution of organisms.

Physical selection can be shown by following out such topics as the relations of animals and plants to the maximum of heat and the minimum of cold, taking the approximate limits of the successful performance of vital functions, and the secondary effects of heat and cold can be exhibited in the more specialized limits of the distribution of forms with relation to temperature in the seas and upon the land. The effects upon animals and plants of the action of gravitation can be illustrated with specimens, such as some shells which become irregular in shape after they become attached, and of the results of experimentation upon plants by Darwin and others. The increase of bulk and weight by growth in proportion to the amount of food taken by the organism can be illustrated in a series of the embryos of plants or of the chick, showing the absorption of the store of food in the seed or yolk and the corresponding increase in size of the plant or animal. The effects of use upon the forms of the teeth, and upon the structure and forms of the bones, and series of specimens showing the most remarkable results of experimentation such as Semper's on Lymnaea, and Schmankewitsch's upon Artemia and Branchipus can be used advantageously. Many parasites also show the effects of the habits of life, and the correlative modifications which are produced in the organism, by changes in their immediate surroundings.

The subdivision which represents the secondary, or organic causes of change is more difficult on account of the confusion which still exists in the minds of naturalists with regard to the law of natural selection. We think, however, that examples of the action and reaction of organisms upon each other are obtainable from the following sources: the numerous cases of mimicry between animals and plants inhabiting the same locality will furnish some of these, and others are to be found by a judicious selection of plants and animals which depend upon each other for food and fertilization. We shall also make an effort to exhibit in this collection clear examples of the broader effects of natural selection, such as the preservation of advantageous differences, taking as examples some of the clearest instances described by Darwin and some fossil examples worked out by the curator.

Mineralogy and Geology.

Prof. W. O. Crosby has spent a proportion of his time during the past year in remodelling the Guide to the Mineralogical Collections of the Society. This is now completed and has been approved by the Council and ordered to be printed at the expense of the Museum appropriation.

The accessions for the year include 120 mineral specimens, which have been added chiefly to the New England Collection, and 300 specimens of rocks, which have been about equally divided between the New England and general collections.

These accessions, with the exception of the New England rocks, have been catalogued and mounted by Professor Crosby assisted by Miss Carter. They have also labelled the collection of Meteorites, about eighty in number, deposited by Mr. John Cummings, and arranged it in the geological work-room. Professor Crosby has, with Miss Carter's assistance, re-arranged the collection of Minerals, so as to correspond with the revised text of the Guide just referred to.

During the fall, this gentleman was engaged, with the permission of the Society and under the direction of the Massachusetts Commissioner, in preparing a collection of the Minerals and Rocks of Massachusetts for the New Orleans Exhibition. Mr. Crosby's expenses, amounting to $250, were paid by the Commissioner (Mr. J. Howard Nichols). The collection includes about 175 lots, consisting of from one to ten specimens each. It has been exhibited at New Orleans in the name of the Society, and on its return from the Exposition, the greater part of the collection will become the property of the Society.

The Geological Department remains as it was at the date of the last report.

Both of these departments are becoming more widely known every year and their usefulness is notably increasing

Botany.

The liberality of Mr. Cummings enables us to report the continued progress of this department. Under his direction, Miss Carter has continued the work of revising and relabelling the general collection.

The Apetalæ and Gymnospermæ have been completed and are reported to stand as follows: The Apetalæ are represented by 32 orders, 235 genera, 970 species and 1,709 specimens; the Gymnospermæ by 2 orders, 13 genera, 47 species and 917 specimens.

This completes the revision of the exogenous divisions which, are reported to contain altogether 152 orders, 2,183 genera 10,913 species and 17,820 specimens. This includes 3,014 varieties and species, which were rescued from the store of duplicates.

The Mosses have also been revised and labelled according to Lesquereux and James' "Mosses of North America."

The herbarium has received twelve specimens of Algæ from Mr. F. S. Collins, four from Miss C. H. Clarke, and a small collec tion of plants from Miss Furbish of Maine. Miss Jack of Canada has added to her collection of North American fruits and forest trees, eight species, and Mr. F. J. Smith of Iowa has given twenty-four models of South American fruits.

There has been a decided increase in the number of persons who have applied for permission to consult or use the herbarium, and the Curator desires to call attention to this fact, since it shows that the usefulness of the department is steadily increasing under its present liberal management.

Anatomical Collection.

The work of arranging and mounting this collection has been completed by Mr. Henshaw and the copy for the printed labels prepared. The collection occupies Room F and half of the Main Hall cases, Nos. 1–26; these last containing the skeletons. There are 103 skeletons as follows:

60 Mammals, 25 Birds, 10 Reptiles,
4 Amphibians, 4 Fishes.[1]

Entering Room F and passing to the right, cases Nos. 1–7 are filled with the Dwight Morphological collection; this consists of nineteen preparations as follows: Frog, Python, Alligator, Turtle, Ostrich, Heron, Owl, Goat, Porcupine, Porpoise, Seal, Sea Otter, Raccoon, Fox, Tiger, Macaque, Mandrill, Gorilla and Man. In this series the specimen of the Frog has been replaced by a larger and more perfect example and that of Man left incomplete by Dr. Dwight has been filled out. It is proposed to add a preparation of a Cod as a typical bony fish. Explanatory labels have been prepared.

In cases Nos. 8–17 are the series of skulls arranged in ascending order; this includes:

12 Fishes, 6 Amphibians, 21 Reptiles,
15 Birds and 252 Mammals.

In cases Nos. 18–21 follow a series of twenty-three sections of mammalian skulls, representing the more important types. On the lower shelves of cases Nos. 22–23 are ninety-seven specimens, showing the osteology of the lower limb. Owing to the limited space in the wall cases the remainder of the osteological series, which should be placed here, is arranged in the flat cases and will be spoken of later in this report.

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[1] This enumeration does not include specimens in the Synoptic or any collection except the *Anatomical proper*.

On the upper shelves of cases Nos. 22–23 and also in cases Nos. 24–28 are ninety preparations of the digestive system, including dissections, dried and inflated stomachs, intestines, etc.; the middle shelves of cases Nos. 29–30 are filled with twenty-eight preparations of glandular organs connected with the intestinal canal and dissections and casts of the urinary organs. Fifty preparations of the respiratory system are on the upper shelves of cases Nos. 29–30.

The lower shelves of cases Nos. 29–30 and also cases Nos. 31–32 are filled with fifty dissections and preparations of the circulatory system.

The nervous system is represented by a fine series (chiefly from the Wyman collection) of ninety-four dissections; these are in cases Nos. 33–34.

The generative system and the series of eggs, larvæ and fœtuses follow in cases Nos. 35–36 and on the lower shelves of Nos. 37–38; of these there are 140 specimens. The upper shelves of cases Nos. 37–38 contain a somewhat miscellaneous assortment of animal secretions, contents of stomachs, etc.

The flat central cases Nos. 1–3 contain the vertebral series, 100 specimens, followed in Nos. 4–6 by the series of lower jaws, hyoidean apparatus and separated skull bones, fifty-eight specimens. The osteology of the upper limb, eighty specimens, are in cases Nos. 7–9. Cases Nos. 10–16 contain 140 specimens relating to the external skeleton, the skin and its appendages, teeth, scales, etc.

The most important contributors to this department, in addition to the Wyman collection, have been Drs. James C. White, H. Bryant, T. Dwight, J. B. S. Jackson, B. J. Jeffries, Samuel Kneeland, C. F. Winslow and Mr. W. H. Dall.

Synoptic Collection.

Miss Martin, under the direction of the Curator, has completed the diagrams necessary for the illustration of the Protozoa and the collection is now sufficiently far advanced to permit of the preparation of a guide. Several Blaschka models have been added.

Paleontology.

Miss Martin, under the direction of Mr. Henshaw, has finished the cleaning and remounting of the American collections.

Mollusca.

Mr. Henshaw spent double time on this collection last year, and, therefore, devoted his whole time to other collections this year.

Sponges.

Mr. Henshaw, assisted by Miss Martin, has completed the mounting of the exhibited collection and has labelled about one-half of the collection not on exhibition. The Curator has identified the larger part of the New England calcareous sponges and some of the Silicea.

Crustacea.

The mounting and cataloguing of the general collection has been finished by Miss Martin, under the direction of Mr. Henshaw.

Insects.

The biological material in cases Nos. 4–12 of Room L has been worked over by Mr. Henshaw, catalogued and mounted.

The general collection of Hymenoptera and Hemiptera have been brought together and partly worked out; of the Hymenoptera we have 350 species identified and of the Hemiptera 250 species.

Teachers' School of Science.

The liberality of the Trustees of the Lowell Fund in defraying the expenses of the lessons and also in continuing to grant the use of Huntington Hall has enabled the Society to persevere in its efforts to extend the usefulness of this department.

At the request of the Superintendent of Public Schools, Mr. Lowell employed the Curator to give a course of ten lessons. The work was directed mainly to the subjects which had been prescribed in the "Observation Lessons" of the Primary, and the "Elementary Science Lessons" of the Grammar Schools, of Boston, and the instruction dealt with as many types of the animal kingdom as could be advantageously studied, with specimens in hand, during the time allotted to the course.

As a natural consequence of this plan the class succeeded in studying less than one-half of the whole number of types formerly used in the precisely similar course given in 1879. The results, however, we believe were more satisfactory than those attained during that course, though the attendance was considerably smaller.

The average attendance was 179.

Number of applications received 750.

Number of tickets distributed.		Zoological course.	
Zoology	837	To teachers,	587
Mineralogy	75	To private addresses complimentary, etc.	250
	912		837

LIST BY TOWNS.

Andover	1	Everett	2	Salem	1
Belmont	4	Hingham	3	Somerville	9
Brookline	4	Hyde Park	26	Stoneham	5
Cambridge	72	Lawrence	1	Wakefield	16
Canton	1	Malden	5	Woburn	12
Chelsea	11	Medford	5	Boston	343
Cohasset	1	Melrose	9	Complimentary	140
Concord	1	Newton	41	Private addresses	110
Dedham	1	Quincy	13		
					837

Twenty-three towns in the neighborhood of Boston.

GRADE OF TEACHERS.

Boston Public Schools.		Out-of-town Schools.	
Superintendent,	1	Superintendents	2
Masters	16	Masters and Principals	45
Sub-Masters	12	Sub-Masters	2
Junior "	1	Assistants	195
Assistants	314		

The course of ten lectures on Zoology were succeeded by a course of ten laboratory lessons in Elementary Mineralogy by Prof. W. O. Crosby. These lessons followed the plan indicated in Mrs. Ellen H. Richards' "First Lessons in Minerals," in Science Guide, No. 11, and had been solicited in order to prepare teachers for giving instruction in "Common Metals, Minerals and Rocks," according to the plan indicated in the schedule of the "Course of Study for the Boston Grammar Schools."

The course consisted exclusively of practical lessons given in the Mineralogical Laboratory of the Massachusetts Institute of Technology, and in consequence of the size of the room, the class was necessarily limited to sixty teachers.

The seats were full and the attendance showed that such courses are more eagerly sought now than formerly.

Lessons given to large audiences have done their share of the work in exciting this interest and we are beginning, also, to reap the benefits of these and of the more direct and earnest efforts made by Miss Lucretia Crocker and Mrs. Richards for the instruction of Boston teachers. The average attendance was sixty-five.

Laboratory.

The laboratory has been used by the following classes: one in Zoology and Paleontology from the Massachusetts Institute of Technology, one in Zoology from the Boston University, both of these being under the charge of the Curator; also one in Botany, and one in Physiology, both of these being under the charge of Mr. Van Vleck.

Annisquam Laboratory.

In the last annual report the Curator ventured to predict that this establishment had reached the lowest point to which it was destined to descend. This prediction has been fulfilled, since the past summer has witnessed a very decided revival in the number and quality of the attendance and the coming summer looks still more promising. This department has at length succeeded so far as instruction and personal effort can make success; the future depends upon other and more material supports.

The Director has felt that his plan was open to criticism, on account of its novelty, for it differed from the ordinary plans of similar laboratories.

It assumed that all persons admitted were capable of conducting their own work, whereas they very rarely were; and it also assumed, on the part of all students, an ability to realize that being taught how to do one's own work was more valuable than the mere information gained. As a rule, the ablest students have acknowledged the benefit of the mode of work, and expressed great satisfaction and gratitude after a short experience.

REPORT OF EDWARD BURGESS, SECRETARY.

Membership.

The Society has lost during the past year five resident members by death, eleven by resignation, while six others have forfeited membership through non-payment of dues, and their names have been erased from the roll. In the death of Dr. Samuel Cabot we lose one of our oldest members. Doctor Cabot joined the Society May 7, 1834, and died April 13, 1885, after a membership of nearly fifty-one years. He held various offices during this long term and was a member of the present Council. The museum and publications bear witness to the extent of his ornithological studies.

The Society also loses by death one Corresponding Member, Prof. Benj. Silliman and one Honorary Member, George Bentham the botanist.

Thirteen Associate and Corporate Members, two Corresponding and three Honorary Members have been elected.

Meetings.

An editorial article in "Science" has recently lamented the small attendance at the meetings of the scientific societies of this neighborhood. With us the chief difficulty appears to be that of providing, in advance, interesting subjects of discussion for every meeting. If the call for a meeting includes no communication, or if the latter happens to be concerning specialties of limited general interest, the attendance is naturally very small, and yet the impromptu talks and discussions at such meetings often prove particularly instructive and interesting. Of the regular sixteen meetings for the past season, the calls for three did not announce papers; the result was that only three or four members attended. The average attendance at the remaining thirteen was thirty persons; the largest attendance being one hundred and sixteen. Twenty-eight communications were made at the above mentioned meetings. It is certainly desirable to consider the question of increasing the interest in the meetings and I believe it is possible to accomplish this.

The Section of Entomology has held only one meeting, at which eight persons were present.

Library.

The number of additions to the Library largely exceeds that of any previous year, the total being 2,655, made up as follows:

	8vo.	4to.	Fol.	Total.
Volumes,	293	107	4	404
Parts,	1,410	299	46	1,755
Pamphlets,	421	30	1	452
Maps, etc.,				44
			Total:	2,655

The new exchanges arranged and new journals subscribed for include the following:

Zeitschrift f. wissenschaftliche Mikroskopie,	Braunschweig.
Verein f. schlesische Insektenkunde,	Breslau.
Royal Society of Queensland,	Brisbane.
Naturhistorisches Museum,	Hamburg.
Royal Society of Canada,	Montreal.
Field Naturalists' Club,	Ottawa.
Ornithologist and Oologist,	Pawtucket, R. I.

Eight hundred and eighty-four books have been borrowed from the Library by one hundred and four persons. These figures remain about the same from year to year.

Seventy-two volumes have been bound.

The Library of the late Dr. Amos Binney deposited in the Society's care by Mrs. Binney in 1856 and numbering 975 volumes besides pamphlets, etc., has been given outright by his son, Mr. Wm. G. Binney, as already announced at a previous meeting.

To Messrs. S. H. Scudder and Samuel Henshaw the Library is indebted for a considerable number of gifts.

Publications.

The cost of the memoirs published a year ago much reduced the funds available for the past season, besides delaying the publications of Proceedings which are now, in consequence, over twelve months behind date. Two numbers of the Memoirs have been issued, one by Miss Hinckley, on the larval history of Hyla Pickeringii with one colored plate, and one by Mr. S. H. Scudder, containing papers on Paleodictyoptera and on the geological history of insects, with four plates. The fine plates illustrating these Memoirs are the gift of the authors.

Two parts of the Proceedings, concluding vol. XXII, have been issued, and eight signatures, which will form the first part of vol. XXIII, are also published.

The Treasurer Mr. C. W. Scudder presented his annual report as follows:—

Annual Statement of Receipts and Expenditures, May 1, 1885.

May 1, 1884, to May 1, 1885.

Admission Fees	$ 55.00
Annual Assessments	1,065.00
Dividends and Income from General Fund	4,066.15
Income from Walker Fund	2.120.00
" " " Prize Fund	328.00
" " " Grand Prize Fund	16.00
" " Courtis Fund	435.00
" " Bulfinch St. Estate Fund	1,986.00
" " S. P. Pratt Fund	636.00
" " Huntington F. Wolcott Fund	593.91
" " Entomological Fund	20.00
Laboratory, Boston University and Fees	2,701.75
Balance	135.85
	$14,158.66

May 1, 1884 to May, 1885.

Museum	$85.41
Library	487.45
Publication and Printing	1,373.84
Salaries and Wages	7,106.67
Repairs of Building	346.06
Fuel and Gas	304.61
General Expenses	789.01
Laboratory	2,855.71
	$14,158.66
Excess of Expenditures over Receipts	135.85

Boston, May 1, 1885.

CHARLES W. SCUDDER,
Treasurer.

The Auditing Committee reported that the Treasurer's accounts were properly cast and vouched, and that they had examined the evidences of the Society's property.

The Society then proceeded to ballot for officers for 1885–6. Messrs. Henshaw and Hinckley were appointed a committee to collect and count the votes and announced that the following were unanimously elected

OFFICERS FOR 1885–86.

PRESIDENT,

SAMUEL H. SCUDDER.

VICE PRESIDENTS,

JOHN CUMMINGS, F. W. PUTNAM.

CURATOR,

ALPHEUS HYATT.

HONORARY SECRETARY,

S. L. ABBOT, M. D.

SECRETARY,

EDWARD BURGESS.

TREASURER,

CHARLES W. SCUDDER.

LIBRARIAN,

EDWARD BURGESS.

COUNCILLORS,

Henry P. Bowditch.
William M. Davis.
W. G. Farlow.
Samuel Garman.
George L. Goodale.
H. A. Hagen.
Henry W. Haynes.
B. Joy Jeffries.
Augustus Lowell.
Theodore Lyman.
Charles S. Minot.
Edward S. Morse.
William H. Niles.
R. H. Richards.
William T. Sedgwick.
N. S. Shaler.
Charles J. Sprague.
M. E. Wadsworth.
Samuel Wells.
William F. Whitney.

MEMBERS OF THE COUNCIL, EX-OFFICIO,

Ex-President, Thomas T. Bouvé.
Ex-Vice President, Richard C. Greenleaf.
Ex-Vice President, D. Humphreys Storer.

Mr. Clifford Warren Smith was elected an Associate Member.

Mr. F. W. Putnam exhibited several bronzes from Peru and gave an account of their composition and the various methods of casting metals as shown by the specimens, several of which were of complicated design and indicated an advance in the art which had not been attributed to the ancient Peruvians. These specimens were obtained from several different sources, and the only reason for doubting their great antiquity was the high state of the art. He hoped to secure further evidence on this point.

General Meeting, May 20, 1885.

Vice President, Mr. F. W. Putnam, in the chair.

Mr. G. T. Barton read a paper on the system of land-holding among the Hawaiians.

Dr. C. S. Minot discussed the phenomena of development and duration of animal life.

Mr. Wm. Newell read a paper on the different action of fresh and salt water upon clays.

Mr. Putnam exhibited several bone fish-hooks in different stages of manufacture. A hole was first bored in a thin splinter of bone and a triangular piece cut out, thus outlining the hook, which was finished by rubbing and smoothing on a stone. These specimens were lately received by the Peabody Museum from Dr. Metz who had obtained them from the "ash pits" in the ancient cemetery near Madisonville, Ohio.

General Meeting, Oct. 7, 1885.

The President, Mr. S. H. Scudder, in the chair.

The President welcomed the members of the Society to the first meeting after the long vacation; and alluded with fitting words to the death of Mr. Henry Edwards of Boston, a life member.

Dr. S. Kneeland described a family of Norwegian Lapps, with a herd of nineteen reindeer which were living in Copenhagen in

April, 1885. The family consisted of a middle aged man and wife, their marriageable daughter of fourteen, and an infant of one year.

They lived in their tent, and their dress and all their surroundings were from Lapland. The man was a little over five feet high, the woman four and one-half, and the girl no larger than one of our girls of eleven. They were dressed in the skin of the reindeer, hair-side out, and looked like small Norwegians or Danes; their hair was light chestnut; the skin, where visible, was as fair as our own; the eyes were grayish blue; the man had a sandy moustache and a slight beard, and was about thirty-five years old; their features were not notably Mongolian, though the face was rather flat, the cheeks a little prominent, and the nose, flat between the eyes, slightly turned up. They were wholly unlike the descriptions in the books, which must refer to the darker Russian tribes. Though small in stature, they were stout and active. The man wore a square cap of red flannel, and the females similar ones, considerably ornamented. The child passed most of its time in a fur-lined cradle, shaped like a large wooden shoe, suspended by a peg from one of the poles over which their woollen tent was stretched; its movements were restricted by tight woollen clothing. The conical tent was about nine feet in diameter, and the same in height, with an opening at the top for the escape of smoke from the fire on the hearth of stones in the centre. The beds were simply a wooden shelf about a foot from the ground, covered with reindeer skin. Their food consisted chiefly of dried and smoked meats and fish, and black rye bread, the last of which they do not get at home. They are fond of coffee, tobacco, psalm singing and catechizing. Though gentle and easily pleased, they are decidedly melancholy and inexpressive.

General Meeting, Oct. 21, 1885.

The President, Mr. S. H. Scudder in the chair.

Dr. S. Kneeland showed models of two memorial gravestones from Central Sweden with Runic inscriptions of the heathen period; both were cut in the body of a serpent or dragon.

General Meeting, Nov. 4, 1885.

The President, Mr. S. H. Scudder, in the chair.

Mr. F. T. Hazelwood, of Lynn, was elected an Associate Member.

Mr. F. W. Putnam referred to the discovery of the mastodon skull at Shrewsbury a year ago, and described the continuation of the exploration of the peat deposit this autumn by the Worcester Society of Natural History, when a human skull was found. As stated to him by Dr. Raymenton, who took out the human skull, both skulls lay on the blue-clay bottom of an ancient pond and were covered with from six to eight feet of peat formation.

Prof. Wm. M. Davis discussed the formation and age of boulder and brick clays.

Mr. Putnam showed an implement chipped from a pebble of black flint, found by Dr. C. L. Metz in gravel, eight feet below the surface, in Madisonville, Ohio. This rude implement is of about the same size and shape of one made of the same material found by Dr. Abbott in the Trenton, N. J., gravel, and is of special interest as the first one known from the gravels of Ohio.

General Meeting, Nov. 18, 1885.

The President, Mr. S. H. Scudder, in the chair.

The President stated that this was the seventy-fifth birthday of Dr. Asa Gray, and showed a photograph of a silver vase presented to him by one hundred and eighty American botanists, in commemoration of the event.

Dr. J. Walter Fewkes gave the results of a paper on deep-sea Medusae, showing and describing some genera collected by the U. S. Fish Commission on the steamship Albatross.

Dr. G. L. Goodale discussed the influence of forests upon the atmosphere.

The President announced the death of Dr. Wm. B. Carpenter, an Honorary Member of the Society.

General Meeting, Dec. 2, 1885.

The President, Mr. S. H. Scudder, in the chair.

Mr. Scudder discussed briefly the classification of fossil scorpions and reviewed Brongniart's recent prodrome of palaeozoic insects.

He also showed a sketch of a wing of a middle silurian insect, from France, which Brongniart thought to be a blattarian, but which seemed to the speaker rather a neuropteroid. Another recent discovery is that of several Coleoptera from the "Kulm-schichten" of Silesia, the oldest known members of this order.

The President then introduced Mr. Frank H. Cushing, who gave a most interesting account of a Zuñi's theories of many natural phenomena and of his ideas about the origin of various animals and plants.

General Meeting, Dec. 16, 1885.

The President, Mr. S. H. Scudder in the chair.

The following paper was read:

Notes on Joint Structure. By W. O. Crosby.

In a communication[1] presented to this Society three years ago, I proposed to recognize three classes of joints, as follows: (1) the parallel and intersecting joints which are especially characteristic of stratified rocks; (2) the non-parallel and non-intersecting joints observed chiefly in eruptive rocks and having their best development in the columnar jointing of the basaltic rocks; and (3) the comparatively unimportant joints parallel with the surface so clearly exposed in many granite quarries, and rarely observed except in very massive, granitoid rocks.

This third class of joints has been explained by Prof. Shaler, apparently to the general satisfaction of geologists, as due to expansion caused by the sun's heat from day to day and from season to season. Hence, in allusion to their origin, these may be very properly designated as *expansion joints.* The second class, after having been for many years variously explained as a species of crystalline or concretionary structure, is now, by the common consent of geologists, regarded as originating in the contraction of the rocks; the contraction being due chiefly to the cooling of eruptive rocks and the dessication of sedimentary rocks. These are, therefore, now properly known as *contraction joints* or *shrinkage cracks.*

The first class is by far the most universal and important. These are the joints properly so-called of Dana and other writers. Many and diverse theories of their origin have been proposed, but geologists have finally settled down to the conclusion that shrinkage is the main cause, and this is the explanation given in nearly all the standard text-books of geology, the first and second classes of joints not being distinguished. Mr. Gilbert, however, showed very conclusively nearly four years ago[1], that the parallel and intersecting joints possess none of the characteristics of cracks known to be due to shrinkage, such as are exhibited in dessicated clays, and that from the nature of the case it is impossible that they should; and also that all other explanations of this class of joints proposed up to that time were alike untenable. The way thus appeared open for a new explanation of ordinary jointing; and the principal object of my paper above referred to was to show that the fractures of the earth's crust, generally believed by geologists to result from the vibratory movements known as earthquakes, must be plane, parallel, intersecting, and normally vertical, possessing, apparently, all the characteristics of parallel joints. So far as I can learn, no serious or unanswerable objections to this earthquake theory of jointing have yet been advanced.

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[1] Proc. B. S. N. H., Vol. XXII, pp. 72–85.

In the American Journal of Science for January, 1884, Mr. Gilbert accepts the theory in its main outlines, but calls attention to some minor peculiarities of this class of joints which were not satisfactorily accounted for in my paper. Successive earthquake shocks are known to traverse the same district in various directions, which often make low angles with each other; but the systems of parallel joints normally intersect at high angles. I explained this disparity as due to the fact that, after the rocks have been broken by one set of joints, the layers or sheets thus formed will break most easily at right angles, so that oblique vibrations may give rise to rectangular fractures and blocks. Mr. Gilbert shows the insufficiency of this explanation and suggests that after one set of joints has been established by an earthquake, a second series of vibrations crossing the path of the first obliquely may have its strains relieved by slipping along existing joints and thus fail to produce a new set; while vibrations at right angles to the original direction would produce strains not at all relieved by the first system of joints, and a second system at right angles to the first would be the necessary consequence.

But Mr. Gilbert also directs attention to the fact that while, as a rule, the angle of intersection of the systems of joints is large, it is occasionally very small, angles as low as 5° having been observed. These exceptional examples seem to vitiate the preceding explanation of the normal intersections, and Mr. Gilbert does not reconcile the two features. It seems to me, however, that they are easily harmonized, if we make the not unreasonable assumption that while oblique vibrations of low velocity would be relieved by slipping along the preëxisting joint planes, vibrations of high velocity would be so nearly instantaneous as to produce fractures normal to their direction before the inertia of the rock in the direction of the preëxisting joints could be overcome.

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[1] Amer. Journ. Sci., XXIV, 1882, p. 50.

Although I have not met any insuperable objections to the earthquake theory, several striking confirmations of it have come under my notice. One of these in particular seems to merit description.

Among the most prominent features of the lower Potomac River are the Nomini Cliffs which form the west shore for about six miles in the eastern part of Westmoreland County, Virginia.[1] They are from one hundred to two hundred feet high and consist entirely of Miocene clays and sands, which are nearly horizontal, dipping gently to the east. In the southern and central portions of the cliff the beds are considerably varied in color and composition and some layers are highly fossiliferous; but the northern part is remarkably homogeneous, consisting from top to bottom of a fine grayish clay in which the stratification is scarcely distinguishable. The slope of the cliffs varies from 50° to 75° and is certainly very steep, considering that the materials are entirely unconsolidated, with the exception of certain limited layers of ferruginous sand and gravel. The face of the cliff is clear and bare in the north part, but farther south it is more or less obscured by a sloping talus. A distinct joint structure is more or less noticeable at all points; but in the northern section, owing, probably, in part to the more perfect exposure of the undisturbed strata, and partly to their greater homogeneity, the jointing becomes a very conspicuous and remarkable feature of the cliff. There are two systems of joints. One of these is sensibly vertical and at right angles to the general trend of the cliff; while the other is approximately parallel with the face of the cliff.

The joint planes are very straight and continuous, and in each set the intervals between successive joints are remarkably regular. These intervals were measured in series of ten each, with the results tabulated below, omitting fractions:

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[1] The observations upon which the following description is based were made chiefly by my father, F. W. Crosby.

	I.	II.	III.	IV.	V.
	Inches.	Inches.	Inches.	Inches.	Inches.
	11	9	10	12	11
	11	8	10	11	12
	11	12	10	11	11
	12	10	12	10	10
	12	8	10	9	12
	13	11	9	10	13
	13	10	8	13	11
	12	11	10	14	10
	9	13	11	13	12
	14	11	9	15	11
Average	11.8	10.5	9.9	11.8	11.3

The general average of the fifty measurements is eleven inches, which differs but little from the average for each series. Five other series of measurements were made at a point one-half mile distant, where the jointing is less regular. The average distances are greater and more variable; but this is partly owing to the cliff being more irregular and crossing the joint-planes obliquely. The joints in the system parallel with the cliff are naturally not so well exposed for observation; but the intervals between adjacent joints seems to vary but little from two feet. This system greatly facilitates the erosion of the cliff. The inclination of the joints is so great that when the waves acting on the base of the cliff have cut through the thickness of one joint layer the whole mass, two feet thick and perhaps fifty or one hundred feet high, slips down bodily, leaving a fresh joint surface to form the face of the cliff. The erosion of the second layer can not begin until the debris of the first is removed, and thus the surface of the cliff is kept straight and parallel with the joint planes. The main channel of the river is half a mile to a mile from the base of the cliff; and the intervening shallow water increases in depth very gradually, covering a smooth, hard floor or platform, which has been formed by the backward erosion of the cliff.

That the joint structure of this formation can not be explained on the shrinkage hypothesis is obvious for several reasons: In the first place, the cliffs are clay from top to bottom, and yet the joints are entirely unlike the shrinkage cracks observed in dessicated clays; but their intersections without interference, parallelism, and regular interspaces are just the characteristics belonging to earthquake fractures in such homogeneous, inelastic material. Again, there is no evidence that the clay has suffered shrinkage from dessication or any other cause. The joints are not open cracks, but mere planes of division, the opposing surfaces being in close contact. Besides, this formation probably always has been essentially superficial, *i. e.*, it has not been subjected to a high temperature or pressure, the diminution of which would be essential to contraction in the absence of dessication. But the clay certainly has not lost volume by drying, for it is still a soft plastic clay; and the joints are most marked at the bottom of the cliff, where the clay is saturated with water.

I wish next to call attention to a good example of columnar or prismatic jointing in the felsite of this vicinity. Although this throws no light, so far as I can discover, upon the origin of joint-structure, it appears to be of some interest on account of the nature of the rock in which it occurs, and, in my opinion, tells quite strongly in favor of the view that our felsitic rocks are eruptive.

In the town of Needham, Mass., there is a large, well defined and isolated area of felsite. The felsite begins in the southern part of Newton, crosses the Charles River just south of Newton Upper Falls, and stretches thence nearly across Needham, the extreme length being about four miles, and the breadth ranging from one to two miles. The village of Needham Plains is situated near the middle of this area, and south and west from this point, especially, the felsite is well exposed in prominent ledges. It is throughout a greenish gray quartz-porphyry, which is often quite green on the weathered surface, showing a tendency to change to pinite. One of the most remarkable features of the rock is its homogeneity, for certainly no other considerable area of felsite in eastern Massachusetts presents so little variety.

The Woonsocket branch of the New York and New England Railroad crosses the felsite area in the direction of its length, and it is along the line of this road, southwest of Needham Plains, that the prismatic jointing has been observed in the felsite. This structure is more or less noticeable in the natural ledges for some distance on either side of the railroad; but it is well exposed, so far as I have observed, only in the cuts on the railroad midway between Needham Plains, and Charles River Village, and near the southern margin of the felsite area, the columns showing along the track for about half a mile. The columns, the observed lengths of which range from three to twenty feet, neither of the natural terminations being exposed, are always straight, and have at all points a very uniform inclination to the north, making an angle of about 10° with the vertical. They are from four to twelve inches in diameter, the greater number being from six to eight inches. The great majority are either exactly or approximately hexagonal on the cross section, although the extreme range is from three-sided to eight or nine-sided columns. They seem to exhibit all the essential characteristics of basalt columns; and, although the masses of felsite in which this structure is well developed alternate with, and shade off gradually into, those in which it is less distinct or wholly wanting, the evidence is perfectly decisive against the view that the columns are due to the intersection of ordinary or parallel joints. The cracks plainly circumscribe the columns, and are not, in any observed case, parallel or intersecting. Although the development of this structure in sedimentary rocks, by dessication, is conceivable, it is certainly extremely rare, if not unknown, in rocks the aqueous origin of which is unquestioned. Hence it seems better to regard this columnar jointing as identical in origin as well as in characteristics with that of the basaltic rocks; especially since the felsite exhibits no other features inconsistent with the view that it is a great lava flow or series of flows.

The columnar structure of this rock is mentioned in my "Contributions to the geology of eastern Massachusetts,"[1] but, regarding the felsite at that time as a sedimentary rock, I failed to appreciate its full significance and importance.

General Meeting, Jan. 6, 1886.

The President, Mr. S. H. Scudder in the chair.

The President announced the death of Prof. C. E. Hamlin of the Museum of Comparative Zoology, a member of the Society for eleven years.

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[1] Occ. Papers Boston Soc. Nat. Hist. *III*, p. 80.

The gift to the Museum by Mr. Charles James Sprague of his valuable collection of North American lichens was announced and a report on the same referred to a subsequent meeting.

The following members were elected:

Corresponding Members: Dr. Charles L. Metz of Madisonville, O., Dr. R. von Lendenfeld of Sydney, Australia, Mr. C. S. Wilkinson of Sydney, Australia, and Baron Ferd. von Müller of Melbourne, Australia.

Corporate Members: Miss Mary A. Wilcox, Mrs. A. L. Boardman, Mr. N. T. Kidder, Mr. Roland Thaxter, and Mr. Robert T. Jackson.

Associate Members: Mr. Arthur C. Boyden, Mrs. Sarah F. Day, Miss L. Theresa Moses and Ensign Wm. E. Safford, U. S. N.

Mr. F. H. Cushing occupied the rest of the evening with an interesting account of some of the Zuñi myths, and their origin.

General Meeting, Jan. 20, 1886.

The President, Mr. S. H. Scudder, in the chair.

Professor William M. Davis spoke of the Chinook winds of the northwest which he regarded as essentially equivalent to the Foehn of Switzerland and similar warm, dry winds of other mountain countries. In a classification of the winds, it belongs with those temporary currents dependent for their motion on the approach of a center of low pressure (cyclonic area), and for their physical peculiarities on the geography of their path. Like the northeast winds of our winter storms, it is propagated backwards. When the air is drawn away from the Piedmont region, a breeze flows out from the valley over the open country; then a current from the mountain crests runs down into the valleys, and at last air from the further side of the range is induced to rise and cross over it. In winter, when the Chinook and the Foehn are more distinct, the vertical decrease of temperature in the atmosphere is relatively slow; and therefore when upper winter air is brought down to lower levels, its temperature rises as it is compressed during descent, and it becomes a warm dry wind. This is the most effective cause of the Foehn as Hann has shown for the Alps. A second cause is found in the retarded cooling of the cloudy, rainy current ascending on the further side of the range, and therefore reaching its crest at a relatively high temperature; so that when descending again as the Foehn, and warming at the more rapid rate characteristic of clear air, it becomes much warmer than it was at its starting point: this explanation was suggested in a general way by Ebel early in this century and by Espy thirty years ago, and has found its full confirmation by Hann and others. A diagram was drawn to illustrate these processes, showing by one set of curves the variation of temperature with height at different seasons, and by other curves the adiabatic changes of temperature in a mass of dry or moist, as ascending or descending air. Detailed observations in our mountain regions are much needed to define the occurrence of the Chinook winds with accuracy.

Dr. S. Kneeland remarked on the habits of our winter ducks, which every evening leave their feeding ground in our harbor and disappear eastward. They probably go to the outer ledges for the night to escape the persecution of gunners.

General Meeting, Feb. 3, 1886.

The President, Mr. S. H. Scudder, in the chair.

The following papers were presented:

MONOGRAPH OF THE HEMEROBIDÆ.

BY DR. H. A. HAGEN.

Part I. Nemopteridæ.

The surprising discovery by M'Lachlan of a species of this family in South America, and his valuable remarks on the other species, have induced me to study the contents of the Cambridge collection, and look over my notes collected since 1866, when I published the "Hemerobidarum synopsis synonymica."

1. N. sinuata Oliv.

I have before me seven specimens from Turkey, coll. Charpentier, labelled by him N. sinuata; Balkan by Lederer; Rumelia coll. Winthem; Syria, two by Lederer, coll. 1863; from Kellenisch, Asia Minor, coll. Loew, the type mentioned by Dr. Schneider, Stett. Ent. Zeitschr., vi, 153. Lucas, Ann. Soc. Ent. 1883, iii, Bull., p. 116, states that Abbé David found N. sinuata very common in N. Syria, north from Antiochia.

Olivier's description, Encycl. méth., 1811, VIII, 178, no. 2, is by no means sufficient to determine the species, which he collected abundantly June 2, on the plains of Troy near the Scamander. The careful description by Rambur, Neur. p. 335, no. 4, is apparently, though not so stated, made from Olivier's type, and is entirely sufficient to distinguish the species. The three black spots of the anterior margin of the front wings at once separate N. sinuata from the related species. As far as I know this species is the first figured, and by various authors.

The oldest figure is given by Petiver, Gazoph. Decas VII, pl. 73, f. 11, called (catal. p. 2, no. 169) Libella Smyrnea perelegans, alis infer. angustissimis. There can be no doubt that the figure represents N. sinuata, though the first large marginal spot is not well shown in the right wing, and the basal transversals are black. These transversals are commonly yellow, with short black triangles at base, but two of my specimens have the black triangle going farther up to the costa, nearly as in Petiver's figures.[1] The plate of Petiver was published between 1704 and 1710.

Ruysch, Thesaurus animal. primus, 1710, pl. 1, D. p. 2, Papilio Turcicus versicolor, is a good figure without doubt belonging to N. sinuata. Linnæus, in Vetensk. Akad. Handling., 1747, p. 176, pl. 6, f. 1 (German transl. p. 196), described a "curious Phryganea," from the Moldau; the figure proves it was N. sinuata. The copy of the figure in the German translation is not so good as the original (the antennæ are very bad), and the copy in Linné, Syst. Natur., edit. Martin Houttyn, seems to be somewhat doctored in the copy in Syst. Nat., edit. Ph. L. St. Mueller, 1775, pl. 24, f. 13. Perhaps it is not well known that Houttyn's edition contains a number of original figures, some of them important, at least botanically. Houttyn is very rare in libraries. I cannot consult the work now, but Mueller's edition is more common and contains a translation of Houttyn and copies of the figures.

Linnæus, Syst. Nat. Ed. x, p. 552, no. 3, has established his Panorpa Coa and quotes Hasselquist, Iter, p. 423, for specimens from the islands Stanchio (Coa) and Metellina. Besides he quotes the Phryganea described by himself (N. sinuata). As Linne's type still exists, it can easily be ascertained if he has combined two species or even three, for in Ed. XII, he quotes specimens from

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[1] The determinations and data given here, when different from those in my Hemer. synopsis, may be accepted as corrections; at the time of the publication of the synopsis I was not able to compare several works.

Spain, sent to him by Loeffling. I have not seen the original edition of Hasselquist's voyage, where his species is quoted as Ephemera Coa; in the French edition, II, 62, no. 109, it is given as Panorpa Coa, but there is nothing more than the name.

Scriba, Beitr. z. Insect. Gesch., 1791, Pars 2, p. 155, pl. 11, f. 1, has a tolerable figure of N. sinuata, described as P. Coa.

Guérin, Hist. nat. Ins. par De Tigny, 1830, VII, pl. 65 bis, f. 3, has given a figure of N. sinuata, but p. 102 only the description of N. Coa. Guérin's figure is the only one known to me with the name of the species. Blanchard's figure in Cuvier, Edit. v, Masson, pl. 102, f. 2, belongs to N. sinuata, but is named N. Coa in the explanation of the plate. Brullé, Expéd. sc. de Morée, p. 276, states that Alex. Lefebvre reports collecting N. sinuata in June on the plains of Modon, Greece, but he adds that he (Brullé) has never met this species in Greece. Mr. Lucas, Ann. Soc. Ent., 1883, Bull., p. 116, speaks at some length on this species found near Antiochia and compares it with N. Lusitanica. Westwood, Ann. Mag. Nat. Hist., VIII, 376, named this species N. Petiveri, after the first figure given of it.

2. **Nemoptera Ægyptiaca** Rbr.

I have never seen this species, which I wrongly united in my synopsis with N. sinuata. Brullé, Expéd. Morée, p. 276, note, remarks that the figure by Savigny, Expéd. Egypte, Neur. pl. 2, f. 15, seems to belong to N. Coa and not to N. sinuata, Rambur, Neur. p. 334, no. 3, has described this species from a colored copy (I have only seen uncolored copies) of Savigny as N. Ægyptiaca. The front wings are without the two black marginal patches, always present in N. Coa. The bands are mostly maculose; the round hyaline spots in the base of the black costal space of the enlarged figure of Savigny are wanting in the figure of natural size, and also in Westwood's N. hebraica, a species from northern Palestine, Thesaur., p. 178, no. 2, pl. 33, f. 5.

Westwood quotes, with a query, N. Ægyptiaca Rbr., as a synonyme. M'Lachlan, *l. c.*, p. 379, states he possesses the same species, "which is undoubtedly that figured by Savigny." It is perhaps not safe to give a negative opinion about a species vouched for by such eminent entomologists without having seen a specimen; nevertheless, I believe more sufficient characters should be given to establish this species.

Westwood's and M'Lachlan's specimens were collected in northern Palestine, flying in a swamp among Papyrus, near the waters of Merom, forming the first basin of the River Jordan, by Rev. D. D. Holland and Pickard Cambridge.

3. Nemoptera Coa L.

I have a pair from the Meteline Island, Winthem's collection. The description by Rambur, p. 333, no. 2, and the fig. pl. 8, f. 3, are excellent, and show the differences between N. Coa and the the other related species. The shorter, more rounded wings, the larger marginal space and the pattern are the prominent characters. The description by Olivier, Encycl. méthod., VIII, p. 178, no. 1, means apparently this species. The figure, pl. 92, f. 4, is bad, but belongs probably to N. Coa. It is not quoted by Olivier (perhaps published after his death) nor by Rambur. Coquebert, Illustr., pl. 3, represents the type of Fabricius, Ent. Syst. Suplem., p. 208, no. 7. The figure is good and important. The works of Fabricius contain some confusion concerning Panorpa Coa. P. Coa, Syst. Entom., p. 314, no. 5, is a copy of Linn. Syst., ed. XII; he describes, p. 202, no. 7, as P. Coa from Bosc's collection, the Linnean species figured by Coquebert, and p. 8, P. halterata, from Barbaria, a new species from Bosc's collection, mentioned later by Klug as N. barbara F. It is difficult to understand how it had happened that he misunderstood Forskål's species persistently.

Brullé, Expéd. sc. de Morée, III, Pt. 1, 275, N. Coa Linn., states that the species is found in Greece on the islands as well as on the continent; very common in middle of May on the plains of Morea, in Messenia later and disappears soon, but appears again in June on the plains, never on the mountains. Coquebert adds the locality Epirus, and Olivier Athens in June, and Negropont. Mr. Blanchard Métamorph., etc., Ins., p. 602, gives a good figure of N. Coa.

Mr. Westwood has named the species N. Coquebertii, l. c., 376, no. 2. He quotes N. lusitanica Rambur, Faun. Andalus., pl. 9, f. 1, which I cannot compare, as referring to this species.

4. Nemoptera bipennis Illiger.

Panorpa bipennis Ill., Ahrens, Fauna Europ. fasc. I, f. 16, 1812.

Nematoptera bipennis Westw., Ann. Mag. Nat. Hist., VIII, 377, no. 3.

Nemopteryx lusitanica Leach, Zool. Hist., II, 74, pl. 85, 1815.

Nemoptera lusitanica Klug, Panorp., p. 93, no. 3. Burm. Hdb., II, 987, no 6.

Nemoptera lusitanica Ramb., Neur., p. 332, no. 1, Faun. Andalus., II, pl. 9, f. 1.

I have before me more than a dozen specimens of both sexes from Portugal, Spain, Andalusia and Granada. It is also mentioned from Gibraltar and France. My specimens from Portugal from the collection of Charpentier are from Count Hoffmansegg, as well as the type described by Leach.

The specimens before me differ largely in size and color. Long. al. ant. ♂ 22–30mm.; ♀ 22–27mm.; al. post. ♂ 41–51 mm.; ♀ 37–50mm. Lat. al. ant. 10–15mm. The color varies from deep yellow to nearly white. I can not now compare Ahrens' Fauna, as I do not know of a copy here; but Illiger's specimens are also from Count Hoffmansegg, and N. bipennis is three years older than Leach's name. The note in the Jahresbericht for 1884, p. 302, by Lucas, Ann. Soc. Ent., 1883, Bull., p. 116, that N. lusitanica is also found in Syria, is an error. Rambur has never given Asia Minor as patria as stated by Mr. Lucas.

5. **Nemoptera Ledereri** De Selys.

I have before me 4 ♂ 1 ♀ from Mr. Lederer, 1865, from Bodz Dagh, fifteen miles south from Smyrna, and a pair from Tultscha, Bulgaria, collected by Mr. Mann, 1865. The first are surely identical with the types of De Selys, which are from the same locality and collector. The pair from Tultscha is an addition of a species to the European fauna; it was given to me by Professor Zeller.

N. Ledereri is described, Ann. Soc. Ent. Belge, 1866, x, 254, pl. 2, f. 1. The figure represents a male of natural size. I have a strong suspicion that Savigny's f. 13, Descr. Egypte, Neur., pl. 2, represents a male of N. Ledereri. It is true that Mr. Audouin, Expl. somm., p. 164, says, nos. 13 and 14 represent, without doubt, the same species, and that both are quoted by Rambur as N. Olivieri. But I think this view cannot be accepted if we compare carefully Savigny's manner of lettering his figures. He has nos. 13 and 14 lettered both with an additional 1 to show that both do not belong to the same species. He has the head lettered in brackets 14.2 and the tarsus 14.3 to show that they belong to no. 14, which is a female of Brachystoma Olivieri. So all the other figures can be accepted as belonging to no. 13, and indeed the last short joint of the labial palpi is found in N. Ledereri. But as I have not now before me N. (B.) Olivieri, I do not know, if this species has similar labial palpi. I may draw attention to the posterior wings in Savigny's figures. In f. 13, they have two darker bands before the tip, the second one very pale (as I find it also in some N. Ledereri) but the tip hyaline; in f. 14, the second band covers the whole tip, which is not hyaline. This does not agree with Olivier's description: "les ailes inférieures sont brunes, depuis la base jusqu'au de là du milieu, ensuite blanchâtres, avec une bande obscure.

The type sent to the Berlin Museum has "posticis basi fasciaque testaceis," and Westwood, *l. c.*, p. 379, no. 14, has the same. The words "alis anticis—lineaque tenui stigmatique albidis" prove that he had a specimen before him, as this character is not mentioned by Olivier nor by Klug. Westwood's specimen must be rather small, as he gives exp. alar. antic. 1¼ unc. = 32mm., whereas Rambur's specimen has the size of N. extensa, 45mm., which agrees nearly with the size of Savigny's f. 14.

It is very fortunate that Savigny's f. 13 has never been named and therefore the name of De Selys will remain.

Long. corp. ♂ 16–17; ♀ 15mm.; al. ant. ♂ 26–32; ♀ 20–21 mm.; lat. al. ant. ♂ 11–12; ♀ 9 mm.; long. al. post. ♂ 56–66; ♀ 38mm.

The smaller dimensions apply to the Tultscha specimens. The female is much smaller, the hind wings much shorter and on the dark bands more dilated, a little angular on both sides. The female seems somewhat related to N. extensa (which is not before me) but from the description it is different.

6. **Nemoptera barbara** Kl.

Klug, Panorp., no. 5. De Selys, *l. c.*, p. 254, pl. 2, f. 3. Westw., *l. c.*, p. 378, no. 7.

Panorpa halterata Fabricius, Entomol. Suppl., p. 208, no. 8.

Nemoptera Algerica Ramb., Neur., p. 336, no. 6. Lucas, Expl. Alger., III, p. 139, no. 49, pl. 3, f. 3.

I have two males from Bona, presented by D. Selys.

7. **Nemoptera gracilis** Hagen.

Panorpa spec. Tollin, Stett. Ent. Zeitschr., 1854, xv, 331.

One male from the Palmiet river between Capetown and Swellendam, in February, on a hill covered with shrubs; very rare. The specimen is in my collection. Mr. Tollin gives the following notes: brown above, yellow below; antennæ thin, setaceous, nearly as long as the body; front wings hyaline, with no spots; neuration fine, one-fourth longer than the body; hind wings very narrow, dilated near the tip, turned in a spiral manner, alternately black and white, three times longer than the body. Long. corp. 19mm.; long. al. ant. 25mm.; long. al. post. 51mm.; long. ant. 18mm.; lat. al. ant. 9mm.; lat. dilatat. al. post. 3mm.

Head reddish-brown above; near each eye a yellow line; eyes globose, a little more than their diameter apart; a brown, round, shining spot behind each antenna; antennæ very thin, a little shorter than the body, brown above, yellow below; first joint much larger than the other, above about quadrangular, shining brown; second short, half as large; all the rest thinner, cylindrical; third twice as long as broad, the following very little longer than broad; the articulations above with a faint, white line; beak nearly as long as head and prothorax, dark yellow, above a brown quadrangular spot on the base; apical part with a brownish tinge; maxillary and labial palpi dark brown with pale articulations; last joint of the labial palpi as long as the preceding one, blackish brown, shining. Prothorax about as broad as long, anterior margin convex, posterior strongly concave; above reddish brown, with a large, lateral yellow band (perhaps, better, thorax yellow, with a broad dorsal reddish brown band); thorax a little larger, yellow, above reddish brown; abdomen unusually long for Nemoptera and very thin, more similar to the abdomen of a Myrmeleon; at the end, which is closed up, two bent-up, cylindrical appendages, closely pressed to the last segment; abdomen above reddish-brown; sides below, and appendages, yellow, with short, blackish hairs, more dense at the tip of the abdomen. Mr. Tollin remarks that the living insect had the abdomen about 2mm. thick; legs long, yellow; first joint of tarsi longer than the three following together; claws strong, blackish.

Wings hyaline; costa straight, more than two-thirds of its length; hind margin strongly rounded; largest part of the wing before the apical third; veins dark brown with fine, dark hairs; pterostigma very small, quadrangular, brown, just above the end of subcostal space; it lies only between two costals and is only half as long as those; subcostal space with a very faint, brownish hue.

Hind wings less than three times longer than the body; the basal three-fifths very narrow, with a faint, yellowish hue and a dark band at the end; veins blackish at base, beyond pale; the other apical two-fifths slowly enlarging, the first and nearly the last third snow white, the middle one black with blackish veins; its basal half is somewhat more enlarged, 3mm., with curved margins, the other part with straight margins; the white tip of the wing is a little shorter than the preceding black part, triangular, on both sides the margin with a slight excision, the tips pointed.

It is rather risky to describe a new species from the Cape of Good Hope, but I am unable to unite N. gracilis with any of the described ones. The long, narrow abdomen recalls N. tipularia Westw., but the coloration is very different, the legs are not short, the fore wings not narrow, and the black band of the hind wings is not divided by a white, longitudinal band, though otherwise similar to N. gracilis. N. albistigma Westw. has a different coloration, the abdomen short and thick, the front wings with a white pterostigma and the hind wings with the white tips much longer than the preceding black part and not dilated and excised at its base. There are no other species known with which N. gracilis can be compared. It is remarkable that N. gracilis is, in some important characters, similar to Stenotaenia Walkeri M'Lachl.[1]

8. **Nemoptera halterata** Forsk.

Panorpa halterata Forsk., Descr. Animal., p. 97, Icon., pl. 25, f. E.

A copy of this figure is in the Encycl. méth., pl. 98, f. 1, named Le Panorpe d'Orient. Forskål represents a male; the appendages are visible, and noted in the description, "chela (flava) bifoliata." Ala ant., 26mm.; al. post., 56mm.; long. corp., 19mm.; long. ant., 22mm.

The dimensions given in the descriptions are considerably larger, and as some characters of the description (oculi coerulei, pupilla nigra; corpus supra coeruleo-fuscum) prove that the living animal was described, it can be supposed that the dimensions there given are the correct ones and that the figure is less than of natural size. Long corp. pollicaris = 27mm.; antennae 28mm.; al. ant. corpore longiores; al. post. tri-pollic. = 82mm.; their length to the first dilatation bi-pollic. = 54mm.

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[1] The author will have to change the name Stenotaenia, because it has been used for a worm by Gervais, 1871, Compt. Rend., Vol. 71, p. 780; *cf.* the Zool. Record for 1871.

Forskål collected his specimen in South Arabia at Beit el Fakih, the celebrated coffee-mart a little north of Mocha.

Olivier, Encycl. méthod, VIII, 178, no. 3, describes as N. halterata Forsk., a species common around Alexandria, Egypt. The type, sent by himself, is still in the Berlin Museum and Klug, Panorp., p. 94, no. 7, decided that it could not belong to Forskål's species and named it therefore N. costata; he remarks that he has nothing to add to Olivier's description. There can be little doubt that this is the species figured in the Descr. de l'Egypte by Savigny, pl. 2, f. 14 (not 13) and later described, by Rambur, p. 337, no. 9, as Nemoptera (Brachystoma) Olivieri, the type of which is in De Selys collection. To this species belongs probably the larva Necrophilus arenarius Roux, Ann. Sc. nat., 1833, XXVIII, pl. 7 and Schaum, Berlin Ent. Zeit. I, 1-9, pl. I, f. 1; types of the larva are in my collection.

Westwood, Ann. Mag. N. H., 1842, VIII, 379, no. 14, under N. Olivieri, long ago united N. halterata Oliv. and N. costata Klug, but the latter name is six years older than Westwood's and Rambur's. Westwood, l. c., p. 378, no. 6, has separated Forskål's species as N. Forskallii, but does not state why he changed the name of Forskål's N. halterata; he adds " nec N. halterata Fabr., Oliv., Dumeril, Klug." It is indeed somewhat surprising that Fabricius' works contain only obvious errors about Forskål's species. He mentions first in Gen. Ins. Mant., p. 245, no. 6, Panorpa halterata; although he quotes Forskål's description and figure rightly, his description ("alis anticis flavo fuscoque variegatis"—Forskål has "alis albidis") shows plainly that he cannot have compared Forskål. As Fabricius at least in his first works described only insects which he was able to examine himself, apparently he had a specimen of N. sinuata, to which the quotation of Forskål was added erroneously. This explains the words "statura et summa affinitas P. Coae." Fabricius repeats the same in Species Insect., 401, no. 6, and in Mant. Ins., 251, no. 6, with the addition mera varietas P. Coae, and unites finally both species in his Ent. syst.

II, 98, no. 7. In his Ent. suppl., p. 208, no. 8, he describes as Panorpa halterata a different species, N. Algirica Ramb.

Klug, Panorp., p. 94, no. 8, unites N. pallida Oliv. with Forskål's species after examining a type sent by Olivier himself and still in the Berlin Museum. Another type of N. pallida, now in the collection of De Selys, is described by Rambur, Neur. p. 335, no. 5, and figured pl. 8, f. 4. Baron De Selys has figured his type, Ann. Soc. Belg., x, pl. 2, f. 4, in natural size, as is stated p. 255. The last figure is of great importance, as Rambur states Préface, p. XVI, that the plate 8 in his work belongs to "plusieurs planches, que je n'ai pas fait faire, et dont l'exécution est très-mauvaise ou inexacte." The figure, pl. 8, f. 2, is obviously bad compared with those of De Selys. It seems to represent a female; De Selys figures a male; the wings are different and decidedly bad. The dimensions of the figure of De Selys are: long. corp. 19mm.; al. ant. 20mm.; al. post. 47mm.; long. ant. 16, but the tip must be wanting, as Rambur says "au moins aussi longues que les ailes supérieures." The descriptions by Oliv., Enc. méth. VIII, p. 179, no. 5, and Rambur differ very little. Olivier notes a small white pterostigma of the anterior wings, and the posterior wings "très-longues, très-minces, à peine plus larges vers l'extrémité, avec une seule bande large, un peu obscure a quelque distance de l'extrémité." Comparing these descriptions and the figure with those by Forskål —alis posticis triclavatis— there can be scarcely a doubt about the distinction of the species. The same view is taken by Westwood, l. c., p. 378 and Rambur. I have never seen a specimen of N. halterata Forsk. Rambur described also the female of N. pallida.

9. **Nemoptera angulata** Westw.

Male. Nemoptera angulata Westw., Trans. Ent. Soc., London, I, Proc., p. 75, Nov. 1835.

Nemoptera angulata Westw., Duncan, Introd., 1840, p. 293, pl. 27, f. 3.

Nemoptera angulata Westw., Ann. Mag. N. H., 1842, VIII, 379, no. 12.

Female. Nemoptera costalis Westw., Trans. Ent. Soc. London, I, Proc., p. 75, Nov., 1835.

Nemoptera costalis Westw., Ann. Mag. N. H., 1842, VIII, 379, no. 13.

Nemoptera costalis Westw., Thesaur. p. 179, pl. 33, f. 6.

Nemoptera costalis Walk., List. Neur. Br. Mus., II, p. 475, no. 15.

Male. Nemoptera bacillaris Klug, Panorp., 1836, p. 95, no. 9, fig. 2.

Nemoptera bacillaris Br. Hdb., II, 986, no. 4.

Nemoptera bacillaris Westw., Ann. Mag. N. H., VIII, 376, no. 10.

Walker, List Neur. Brit. Mus., II, 475, no. 16, quotes this species as Nemoptera angula Westw. I have never quoted Walker's List except when the presence of types is stated; which is done with seven species. I have, too, not quoted Westwood's monograph in Proc. Zool. Soc., 1841, part IX, 9–14, because it is identical with the monograph in the Ann. Mag. Nat. Hist.; I think the latter was perhaps published some months later.

I have before me male and female from Port Natal collected by Drège; the male from the collection Winthem has a label in Klug's handwriting, "bacillaris" on the pin; the female I bought from the duplicata of Drège, in 1849; it has no. 1,535 on the pin; this number in the Catalogue of Drège's duplicata, published by Klug, 1841 (fasc. IV), is stated to be N. bacillaris Kl. Therefore, the identity with Klug's species is certain; besides I bought three specimens more with the same number, which are N. latipennis Br., which Klug does not seem to have separated from N. bacillaris.

I have the strong opinion that the three species characterized by Mr. Westwood, 1835, in the Proc. of the Trans. Ent. Soc., are from the same lot and the same collector. Drège's duplicata were largely sold since 1835, and the catalogues (I have not the three first numbers before me) stated that the insects were from west Africa, and gave no names for a number of species, which were later published. Finally, Westwood's three species are just the same as I find represented among the duplicata, to wit, angulata (= bacillaris), of which is stated in brackets "an mas praecedentis?," costalis, which is very probably the female, and Africana (= latipennis). Perhaps Prof. Westwood will be able to decide whether I am right or not.

Male, long. corp., 20mm.; long. al. ant., 29mm.; long. al. post., 66mm. Head above light reddish brown, before the antennae and below yellow, with a brown ring just before the antennae; the large eyes are scarcely more distant than its diameter;

vertex much deeper than the eyes; behind each antenna a large, hollow groove, both grooves separated by a sharp, wedge-shaped carina; the transversal line of the occiput if present, not visible from above; the small lateral impressions nearly wanting; antennae (apical half wanting, in Klug's figure 22mm. long) light reddish brown, below paler; first joint twice as thick as the rest, keg-shaped; second joint annular; the following twenty-two joints a little thinner, cylindrical; third longer, fourth short, the following successively longer; mouth yellow, an indefinite transverse band at the base and a brownish shade on tip; labial and maxillary palpi blackish with white articulations; mentum blackish before the labium; prothorax short, much narrower than the head, much enlarged behind, dirty yellowish, with a brown band in the middle and one on each side; thorax large, same color, no lines visible (in bad condition); abdomen short, above two maculose yellow bands separated by a large black band; a similar black band on each side; below reddish brown; appendages pale yellow with black hairs. Legs dark yellowish, long, with black villosity; first joint of tarsi as long as the others together; claws thin, black.

Front wings, large, three times longer than broad; front margin straight to tip, hind margin curved so that the greatest breadth is in the middle of the wing; tip sharply pointed; subcosta and mediana yellow, the long space between them yellowish brown; the other veins are brown; thirty costals to the small brown pterostigma, which is enclosed only between two costals; there is a small round yellow spot connected with the subcosta in each of the cells between the costals from the base nearly to the pterostigma; the extreme base of the hyaline wing, yellowish to the hind margin. Hind wings very narrow, the two basal thirds yellowish, followed by a brown band; beyond it a little wider, white, twice as long as the brown band, narrowed to the pointed tip.

Westwood in his first diagnosis calls the pterostigma black, but has later corrected it to brown. Probably his specimen was darker than mine to judge from his figure in Duncan. Klug's figure agrees with my specimen except that he describes a milk white pterostigma before a blackish spot; as my specimen is very pale and probably the colors immature, the milk white is very little to be seen. At least there is no doubt about the identity, as my specimen is labelled by Klug himself, and the white pterostigma may have been taken from N. Africana, which he had not separated.

Female. Long. corp., 11mm.; al. ant., 24mm.; al. post., 48 mm. Smaller, but in color and shape exactly like the male, except the following differences: Head smaller; eyes much smaller and distant twice their diameter; head not depressed above, on the occiput an engraved transverse line; on each side near the eyes an impressed hole (the head with the eyes is 2mm. broad; the head of the male, 3mm.). Prothorax much broader behind than long, dirty-yellow, with a black band in the middle and one on each side; thorax same color, with a large brown median band, interrupted on the suture and on each side a brown band; abdomen in bad condition, with similar colors and bands; legs similar; front wings similar but the tip slightly rounded; a small darker shade below the mediana after the pterostigma; a yellowish round spot in each costal-cell nearly to the pterostigma; hind wings similar but shorter.

I have no doubt that this female belongs to the male, though the wings are rounded at tip instead of pointed. Westwood's figure of N. costalis in the Thesaurus and his description agree perfectly with the specimen before me; the white nebula is partly visible after the pterostigma; Westwood's specimen is a little larger. The type of Westwood is preserved in the British Museum.

10. Nemoptera Africana Leach.

Nemopteryx Africana Leach, Zool., Miscell., II, 74, pl. 85, lower fig.

Nemopteryx Africana Griffith, An. Kingd., xv, 324, pl. 105, fig. 4.

Nematoptera Africana Westw., Ann. Mag. N. Hist., VIII, 378, no. 9.

Nematoptera latipennis Br. Hdb., II, 986, no. 5.

Nemoptera Africana Walk., List. Neur. Brit. Mus., II, 475, no. 14.

(There is a good copy of Leach's fig. in Bertuch's Bilderbuch, vol. x.)

I have before me 1 ♂ and 3 ♀ all from the Cape of Good Hope, Drège; long. corp., 15 to 10mm; al. ant., 24 to 20mm; al. post, 52 to 42mm.

Very similar to N. angulata in color and shape, but smaller. The eyes of the male are smaller, more distant, about twice their diameter, the vertex less deepened ; head fulvous, more yellowish below ; grooves behind the base of antenna dark brown, both grooves separated by a less sharp carina ; the transverse line of the occiput not visible from above ; antennæ fulvous, base yellowish, longer than the body with more than sixty joints ; the elongate fovea on each side just on the apex of the front and the base of the epistoma, with a yellow, bijointed, very thin cylindrical palpus ; this palpus is present on each fovea, standing in the lower end of it vertically. I do not know if it is evaginated out of the fovea, and I must say that among forty specimens before me, this and N. filipennis are the only ones showing this palpus ; this fovea is present in other Hemerobina, very large in Palpares ; also in Pseudoneuroptera in Odonata. Its development in Corydalis is very peculiar ; it forms in the imago a complete perforation and was first mentioned by Dr. S. S. Haldeman in Proc. Acad. N. Sc., Philad., 1846, II, 192, and later in the monograph p. 160. "They are present in both sexes, and are sufficiently large at the narrowest part to admit a bristle, and from this point they enlarge upwards and downwards. They are situated at the internal extremity of a transverse impression above, and in the angle of a curved fissure beneath, which separates the post-mentum from the cranium. There is no interruption in the solid exterior of the head as it passes through and lines this perforation, so that thus far it has afforded no additional information as to the functions of the antennae. (The perforation in Corydalis is at the anterior base of each antenna)." M'Lachlan has mentioned it in Stenotaenia, l. c. p. 376.

As far as I am able to state now, this fovea belongs really to the base of the epistoma and is prolonged externally on the adjacent apex of the front or beneath its anterior margin and covered by it, as in Odonata. I believe I remember a suggestion that it is connected with one of the senses, but I am now unable to find where or by whom. The presence therein of a kind of palpus (I do not know how to call it otherwise) is so extraordinary, that I would not have mentioned this fact, if I had not ascertained it by the most careful examination with the compound microscope, and if it were not present on both sides exactly in the same manner.

Mouth yellow, last joint of labial palpi blackish. Prothorax short, narrower in front, yellowish, with a brown band in middle and one on each side; thorax yellowish, with a large but somewhat indefinite brownish band in middle and one on each side; abdomen (not in good condition) yellowish, with a broad black band in middle and one on each side; end of abdomen and appendages yellow with black villosity, but it cannot be well made out. Legs long, yellowish, claws black, first joint of tarsi a little shorter than half the length of the tarsus.

Front wings three times longer than broad; front margin straight in the basal two-thirds, then curved to form an elliptical apex; hind margin curved, so that the greatest breadth is in the middle of the wing; subcosta and mediana yellow, the other veins brown; subcostal-space yellowish with a very faint tint of brown, which passes above in the costal-space but only along the costals, so that nowhere is an isolated yellowish spot in the costal-cells to be seen; 34 costals between the base and the small milk-white pterostigma, which does not reach the front margin; beyond it a brownish cloud to the tip; the extreme base of the hyaline wing a little brownish. Hind wings very narrow, the two basal thirds yellowish, more brownish at the base, followed by a long brown band; apex white, twice as long as the brown band, narrowed to tip.

Female. Similar to the male; head smaller; eyes a little more distant, vertex not depressed; below it a narrow blackish middle line to occiput; a curved tranverse impressed line on occiput, on each side with an impression near the eyes; fovea open without palpus; antennae probably shorter, but not entirely perfect. I find no other difference.

I have no doubt that male and females belong together, though two of them are a little larger than the male. All are from the same place and collector, and the number given to them shows that Klug had taken them to belong to his N. bacillaris. I believe that all belong to the true N. Africana Leach, and as the type, according to Walker, is still in the British Museum, this can be easily ascertained. This species is undoubtedly N. latipennis Burm., also from the same place and collector, and from the same lot of duplicata of which my specimens were taken. Leach's type is from Sierra Leone, and he speaks about a specimen from Egypt, received by Macleay from Savigny.

11. **Nemoptera remifera** Westw.

Nemoptera remifera Westwood, Thesaur., p. 179, no. 5, pl. 33, f. 9. In the collection a male from the Cape of Good Hope, N. capensis Hesse. Long. corp. 13mm.; long. al. ant. 21mm.; al. post. 46 mm.

Luteo-fulvous; similar to N. Africana, the head and eyes alike; antennae (not complete) 45-jointed; maxillary palpi blackish; thorax without bands, prothorax broader in front; abdomen more brownish; legs long; tarsus with first joint half its length; front wings hyaline, front margin straight to pterostigma; hind margin slightly curved, greatest breadth in the middle of the wing, which is a little broader than one-third of the length (8mm.); tip elliptical; about all veins yellow; subcostal space light yellow, also around some of the costals; twenty-four costals to a small brown pterostigma, which does not reach the front margin; the cells of the wing larger than and not so numerous as in N. Africana; hind wings very narrow, more than the basal two-thirds yellow, then a brown band 6mm. long, followed by milk-white; a little enlarged and longer to the pointed tip.

I believe this to be Westwood's species; the wider venation and smaller number of costals, the brown pterostigma without darker nebula separate this species from all related ones. The specimen is at least eighty years old, so the color may have disappeared. It was in Winthem's collection with the label N. capensis mihi Hesse.

Mr. Fred. Hesse, of Brunswick, was in the beginning of this century a Lutheran pastor in Capetown (see Illig. Mag. VI, 229) and the larger part of all insects from the Cape in the Helwig-Hoffmansegg collection, now in the Berlin Museum, was probably sent over by him.

12. **Nemoptera Huttii** Westw.

Nemoptera Huttii West., Proc. Ent. Soc., 1847, 27, pl. 8, f. 1.
Nemoptera Huttii Walk., List Neur., Brit. Mus., 476, no. 19.

Taken near a swamp on the road between Perth and Guildford in western Australia by Governor Hutt and communicated to Mr. William Spence, by whom it was named in MS. A second specimen is in the British Museum. I have a specimen from the Swan

River, collected by Dr. Preiss, formerly in Winthem's coll., but the head and prothorax wanting. This specimen is a male as well as the specimen figured by Mr. Westwood.

Long. abdom. and thorax, 11mm.; al. ant., 18mm.; al. post., 28mm.

"The parts of the mouth are exposed and the antennae much more incrassated than in N. Coa and its allies."—Westwood.

According to the figure the thick black antennae are a little shorter than half the length of the body, and the prothorax is black, yellow on each side. Mesothorax thick, black above, yellow laterally below the wings and on the ventral part; on the sides two black angulose bands, connected anteriorly, a black line on the lateral suture and the stigma largely black; some white villosity on the thorax above and laterally; metathorax short, above black with median dorsal band and one on each side yellow; front margin transversely yellow; the sides and ventral part yellow with some indefinite blackish marks above the legs; abdomen long, narrow, above black, the transverse sutures and the lateral margins finely yellow; below bright yellow with a longitudinal black band not far from the lateral margin; a fine black villosity on the abdomen; superior appendages yellow, internally black, twice longer than the last segment, broad at base, then cylindrical, curved inward and downward, tip rounded; viewed laterally, they are inserted in a short, basal joint, not to be seen from above; inferior appendage yellow, spoon-shaped, one-third shorter than the superiors; the appendages covered with long black hairs. Legs (first pair wanting) long, yellow, with black hairs; a black angular band at the base of coxa, an external black point on the trochanter; femur, with the apical part nearly one-fourth of the length, black above, and the intermediate femur brownish anteriorly; tibia black on tip; tarsus with first joint as long as the other together; claws black. Front wings hyaline, three times longer than broad, front margin nearly straight to the elliptical tip, hind margin curved so that the greatest breadth is about in the middle of the wing; veins brown, except the costa, subcosta and mediana, which are yellowish white; the subcosta below at base black; twenty to twenty-one blackish costals before a very small brown pterostigma, which is just above the end of the hyaline subcostal space and does not reach half the breadth of the costal space; venation wide, cells larger; hind wings short, about three times the length of abdomen, blackish brown, except on the base, which is white, between very strong black and black-haired veins and the extreme pointed tip which is snow white; a little beyond the middle the wings are largely bi-dilatated, the first longer and broader (5mm.), the veins white in the middle with oblique excisions between the dilatations.

13. Nemoptera filipennis Westw.

Nematoptera filipennis Westw., Ann. Mag. H. H., 1842, VIII, 380, no. 19.

Nemoptera filipennis Westw., Orient Cab., 70, pl. 34, fig. 6.

Nemoptera filipennis Walk., List. Brit. Mus., II, 476, no. 18.

Prof. Westwood described the species from the collection of the late Mr. W. W. Saunders, and the male before me is a precious present from that gentleman, who was during his whole life the generous patron of students of natural history. In the Orient Cab. is described a specimen from Central India collected by Mr. Hearsay in Hope's collection, and in the British Museum is a specimen from N. Bengal from Miss Campbell's collection. Long. corp. 7mm; al. ant. 10mm; alt. post. 25mm.

Male. By a sad chance the head and the prothorax of my specimen were lost when I tried to verify my observations made by a strong lens, with the compound microscope. Head yellow with some brownish marks; eyes large, globose, distant as much as their diameter; in the little fovea on each side of the beak a fine erect palpus. I have seen it undoubtedly similar to a fine spine. Thorax thin, yellow; abdomen brown, the basal half of the segments pale yellowish; superior appendages forming a pale forceps; legs long, thin, yellowish; front wings three times longer than broad, front margin straight to the pterostigma, hind margin curved; greatest breadth beyond the middle of the wing; apex parabolic; veins pale yellowish; fifteen costals to the pterostigma, the eight nearest to the base straight, forming quadrangular elongated cells, the following oblique, nearly together; pterostigma large, dark brown, filling seven narrow cells; venation large; hind margin of the wing, with a dense fringe of long brownish hairs; hind wings long, very narrow, basal half brown, with a brown fringe, apical half white, pointed on tip.

M'Lachlan has proposed, l. c., p. 378, a new genus Croce for this species and its allies.

Mr. Wesmael, Bull. Acad. Bruxelles, 1836, III, 162, pl. 6, fig. 1, published a new Lepidopterous genus Himantopterus (fuscinervis) from Java in the collection of Mr. Robyns. When I had the pleasure of visiting this distinguished entomologist in 1857, he drew my attention to this insect, and stated that he believed it to be a Nemoptera near N. filipennis Westw. He added that for this reason he had never given a copy of the separata to entomologists, and bringing the whole pile, he stated that I was the first to have one. On my asking if I could see the type, he said it was destroyed by pests. (Stett. Ent. Z., 1859, p. 412). So in 1866, Syn. Hemerob., p. 422, I introduced Himantopterus among the Hemerobids and N. filipennis to this genus. Prof. Westwood, Pr. Ent. Soc., 1877, 437, after the examination of the type, showed conclusively that Himantopterus was a Lepidopteron, to which Mr. M'Lachlan, Cpt. Rend, Soc. Ent. Belge, 1877, 56, assented. I remembered then my note in the Stettin. Ent. Zeit., which was mentioned Cpt. Rend., l. c., 70; of course I said in good faith, that I never saw the type. Perhaps a year later in studying Wesmael's remarkable deformity of Limenitis populi with the larval head also from Mr. Robyn's collection, I remembered distinctly that the type had been seen by me when I had the pleasure to be in the Museum in Brussels with Mr. DeBorre on my last hurried trip to Europe. Then it occurred to me that Mr. DeBorre had also shown to me Himantopterus and that he had asked me courteously to write down my determination. If that is so,—the lapse of sixteen years may explain my uncertainty,—it is only a proof how imprudent it is to write down determinations during a hurried trip and without careful examination of the specimen. I have only to frankly apologize and to ask the favor to throw away my label. I will not try to shield my blunder with the statement that I had at the time not seen my collection, which was left behind in Europe, for four years, nor with the fact that I have never considered nor published, that both species are identical.

14. Nemoptera pusilla Tasch.

Nematoptera pusilla Taschenberg, Zeitsch. f. Naturw., 1883, 56, 183. Collected by Dr. E. Riebeck on the island Socotra. I have not seen it. "Smaller than the smallest Chrysopa; white, the beak above blackish and a lateral blackish band on each side from behind the head to tip of abdomen, except on the metathorax;

legs and antennae (incomplete) with dark hue; front wings hyaline, iridescent; pterostigma white; hind wings bristle-shaped, 24mm. long; long. corp. 7mm; exp. al. ant. 20mm."

I may draw attention to the possibility that N. alba Oliv., and N. pusilla are identical. The only difference is the black lateral bands by N. pusilla. As far as I know N. alba is not represented in collections, and has not been seen by anybody except Olivier. It was very common about the end of May in Bagdad.

I cannot give anything more on the classification of the other species, as a number of them are not before me; it would be necessary to examine both sexes to arrive at a satisfactory conclusion. Therefore I give only a list of those species, which I believe to be genuine.

NEMOPTERA.
1. sinuata Oliv.
2. Coa Linn.
3. Ægyptiaca Rbr.
4. bidens Illgr.
HALTER.
5. barbara Klug.
6. Ledereri De Selys.
?.
7. extensa Oliv.
8. dilatata Klg.
9. Huttii Westw.
?.
10. imperatrix Westw.
?.
11. pallida Oliv.
SUBG. NOV.
12. halterata Forsk.
13. angulata Westw.
14. Africana Leach.
15. remifera Westw.
16. gracilis Hag.
17. albostigma Westw.
18. tipularia Westw.
BRACHYSTOMA.
19. costata Kl.
20. Walkeri M'Lachl.
CROCE.
21. filipennis Westw.
22. aristata Kl.
23. alba Oliv.
24. pusilla Tasch.?
25. setacea Kl.
26. capillaris Kl.

THE BOW AND ARROW UNKNOWN TO PALAEOLITHIC MAN.

BY HENRY W. HAYNES.

My attention has been called to some remarks of Dr. A. A. Julien at a meeting of the New York Academy of Sciences, April 7, 1884, printed in their Proceedings, III, p. 81, in which he takes exception to a statement contained in an article by me in the American Antiquarian, for the preceding month (VI, p. 137). In criticising President Warren, of the Boston University, for misuse of language in calling the builders of the pyramids of Egypt "palæolithic Africans," I had insisted that the word "palaeolithic" is a technical term of science, as strictly limited in its signification as are the words palaeography or palaeontology. As defined in Ogilvie's Imperial Dictionary, it means "belonging to the earlier stone period of prehistoric history;" and "palaeolithic man" is there quoted as signifying "man who lived contemporary with the extinct mammalia." Doctor Julien states that he entirely agrees with my general views, but that he takes exception to the closing paragraphs, viz.: "However long ago it may have been in the 'dark backward and abysm of time' the palaeolithic man, a savage hunter armed with his rude axe of roughly chipped stone, once dwelt in the valley of the Nile as well as in that of the Somme. President Warren claims to have 'a great respect for the palaeolithic man,' and he can hardly find words to express his admiration for the marvellous skill exhibited by him in fashioning the 'prehistoric arrow-head.' But, unhappily, in point of fact, 'the palaeolithic man' was no more capable of making a stone arrow-head, than he was of building a pyramid."

The report continues: "In reply to the statement in the last sentence quoted, Doctor Julien exhibited several specimens of chipped arrow-heads and lance-heads from the lowest gravels of St. Acheul, one of which had been dug out before his eyes. Such remains were not common, chiefly, perhaps, from the difficulty of distinguishing objects of such small size, fragile nature and rude type among the flint nodules; but there were many such on exhibition in the Museums at Abbeville and Amiens, the Blackmore Museum at Salisbury, etc. There were even several arrow-heads figured by Boucher de Perthes among his first finds in the first volume of the "Antiquìtés Celtiques et Antédiluviennes," 1849, Plates 29 and 30, described in Chapter 19. The form of the arrow-heads was sometimes that of simple, rude flakes, slender and wedge-pointed; but a more characteristic and unmistakable variety, represented by the specimens exhibited, was heart-shaped, *i. e.*, triangular, with a basal indentation or nick. The evidence M. de Perthes had brought forward and fully illustrated in all the volumes of his work, of the discovery of rudely formed palaeolithic knives, awls, augers, hammers, saws, etc., had been fully confirmed by later examination of the oldest gravels. In the valley of the Somme, atleast, the palaeolithic inhabitant was far more than a 'savage hunter,' and found in the flint a material easily chipped into many useful forms beside that of a 'rude axe of roughly chipped stone.'"

Now, I make bold to assert that Doctor Julien never saw in any one of the Museums referred to by him one single specimen, labelled " arrow-head," placed among the *palaeolithic* objects. As for the " specimens of chipped arrow-heads," one of which he saw " dug out before his eyes from the lowest gravels of St. Acheul," I must remind him that the age of beds of river-gravel is in inverse ratio to their position in the valley. The oldest gravels are the highest up the bank ; and it is possible he may have seen a neolithic, chipped arrow-head dug out of the bed lowest down and nearest to the river, and consequently the latest deposited. Moreover, I think it would have been better if Doctor Julien in his reference to Plates 29 and 30 of the first volume of Boucher de Perthes celebrated work, which are described in Chapter 19, of the same volume, had quoted the exact language used by the author in his description. He says : " No. 11 represents arrow-heads, or rather something resembling them in shape ; for, with the exception of the smallest, I doubt if they could ever have served for weapons," p. 407. In his second volume, where he is describing with much greater particularity the objects represented upon this same Plate 19, he calls them " those heavy, rude lance-heads, serving for projectiles," p. 261. The following chapter, No. 28, is entitled " Arrow-heads of stone and bone," and begins as follows : " Of stone implements those which are met with most frequently in countries very anciently inhabited, and which vary most in shape, are arrow-heads. The first, as we have said, heavy and rude, were not provided with shafts ; they were thrown by hand, or by the help of a wooden tube. But the range of these projectiles could not have been large, or their direction very sure. Afterwards the heads were made lighter and they were placed at the end of reeds, to which feathers were added ; and they were then cast by the help of a bow," p. 278. Thus it is evident that Boucher de Perthes did not have in mind " arrow-heads," but " lance — or javelin — points" when he was describing those heavy, triangular, pointed flakes, which are not unfrequently found in the gravel-beds of the Somme, associated with the rude, heavy, chipped palaeolithic axes, of the so-called type of St. Acheul. That implement is generally regarded by archaeologists as the one used by man in his earliest stage ; but members of this society may recollect that some time since I suggested reasons for not considering that type of implement to be the primitive one (Proceedings of Boston Society of Natural History, xxi, p. 382).

I have brought here for your inspection several of these flakes, which I procured at St. Acheul at the same time that I saw dug out these two veritable specimens (although they are unfortunately broken ones) of the carefully chipped, well-shaped, palaeolithic axe of the type of St. Acheul. Here is also for comparison a perfect example of such an axe, as fine a specimen as has ever been discovered. The flakes are evidently pieces struck off from a block of flint during the process of fashioning an axe. Some of them bear plain marks of having been used for cutting, or some other purpose, and such are sometimes called "knives." I think, however, it is better to call them "used or worn flakes;" for they may have subserved some other purpose than cutting. The term "knife," I think, had better be restricted to the more carefully made sort of instrument, of which I have a specimen here.

Rude and heavy flakes, like these, are what are commonly found in the river-gravel beds. Occasionally, however, one of smaller size and lighter, is met with, somewhat resembling in its shape a roughly-made arrow-head. But such objects exhibit none of that "marvellous skill" in their fabrication, for which President Warren professed such "great respect." He was evidently thinking of such beautiful objects as we sometimes see now set in gold and worn by ladies as brooches. But such finely chipped arrow-heads are as characteristic of *neolithic* times, as are the dolmens themselves. The finding of an occasional flake, shaped like a rude arrow-head, is very far from proving that savage man, at the very outset of his career, had developed mental capacity sufficient to enable him to invent so complicated an instrument as the bow and arrow.

In fact, so great a discovery did this appear to the late Lewis H. Morgan, that he uses it, in his great work upon "Ancient Society," to mark his "Third Division, or Upper Status of Savagery." This, he says, "commenced with the invention of the bow and arrow, and ended with the invention of the art of pottery," p. 10. "As a combination of forces," he continues, "the bow and arrow is so abstruse that not unlikely it owed its origin to accident. The elasticity and toughness of certain kinds of wood, the tension of a cord of sinew or vegetable fibre by means of a bent bow, and, finally, their combination to propel an arrow by human muscle, are not very obvious suggestions to the mind of a savage. As elsewhere noted, the bow and arrow are unknown to the Polynesians, and to the Australians. From the fact alone it is shown that mankind were well advanced in the savage state, when the bow and arrow made their first appearance," p. 21 (note). Oscar Peschel, however, thinks that the reason why the bow and arrow were not found in use among the Polynesians at the time of their discovery was because it had gone out of use, on account of there being no large animals on their islands to hunt. They once had it, but its skilful use requires constant practice. "Races of Man," p. 183.

Let me conclude by quoting the opinion of two other eminent archaeologists upon this question, whether the palaeolithic man was acquainted with the use of the bow and arrow.

John Evans, the greatest authority upon the subject of stone implements, in his exhaustive and masterly treatise upon "The Ancient Stone Implements of Great Britain," says: "In the river-gravel deposits nothing that can positively be said to be an arrow-head has as yet been found, though it is barely possible that some of the pointed flakes may have served as such," p. 322.

Gabriel de Mortillet, the eminent lecturer in the School of Anthropology at Paris, and well known as the Curator of the prehistoric department in the great Museum of St. Germain-en-Laye, says: "Some palæethnologists contend that the Chellean epoch had no other implement than the almond-shaped axe, chipped on both sides. Up to the present time at Chelles, no other worked object has been found in the ancient gravel-beds. But it would be quite natural that some worked flakes should be discovered. The surprising thing is that they have not yet been found. Indeed it is impossible to make an almond-shaped axe without producing numerous flakes, bearing traces of working and having bulbs of percussion. What is wanting is worked flints other than the axes. At St. Acheul, a station which belongs to the end of the Chellean epoch, and where consequently there already begins to be an intermingling of forms, stone implements, other than the characteristic, almond-shaped axe, are extremely rare. Not even the simple flakes, which must have been produced in abundance in chipping the large objects, are common. The almond-shaped axe of the Chellean period mostly prevails, which shows clearly that it is the oldest form, and that it began by reigning as master," Le Préhistorique," p. 143.

In the beautiful work by the same author, made up of an extensive series of plates in which are represented all known objects belonging to prehistoric times, entitled "Musee Préhistorique," Plate 11 is devoted to such pointed implements, from the river-gravels of the quaternary period, as are shaped like arrow- or lance-heads. But all of these are set down as belonging to the second division of the *Palaeolithic Period*, the so-called *Epoch of Le Moustier.*

I think this will be sufficient to vindicate my statement, possibly a little exaggerated, that "the palaeolithic man was no more capable of making a stone arrow-head, than he was of building a pyramid."

Dr. S. Kneeland read a paper on the Santhals, an aboriginal tribe of Eastern Bengal.

General Meeting, Feb. 17, 1886.

The President, Mr. S. H. Scudder in the chair.

Dr. W. G. Farlow spoke of the collection of lichens belonging to the Boston Society of Natural History. This consists almost wholly of the lichens from the herbarium of Thomas Taylor, a donation by Mr. C. J. Sprague, No. 676 of the donation book of the Society, and the valuable collection of North American lichens recently presented to the Society. The first named collection belonged to Mr. Thomas Taylor who died at Dunkerran, Kenmare, Ireland, in February, 1848. A physician by profession, he filled for a short time the position of lecturer on Botany and Natural History in the Royal Cork Scientific Association but soon withdrew to private life. As a botanist he is best known by his works on mosses and hepaticae and he was a co-worker with Sir W. J. Hooker in this department. He also described the lichens published in the Flora Antarctica. On his death, his collection was offered for sale and the whole or, at any rate, a portion of it was purchased by Mr. John Lowell of Boston who presented the lichens to this Society and the Hepaticae to the herbarium of Harvard University. The advertisement of the sale of Hooker's Journal of Botany stated that there were 2251 sheets of lichens. They include many beautiful specimens embracing the types of the Antarctic lichens and also some valuable specimens collected by the early botanists and explorers of this country among whom may be mentioned Drummond, Richardson, and Menzies.

After the reception of the Taylor collection it was sent to Prof. Edward Tuckerman who revised the determinations of the species and enriched it with notes of his own.

The first collection presented by Mr. Sprague included principally species collected and named by Prof. Tuckerman, Mr. J. L. Russell and Mr. C. C. Frost. This donation apparently included a set of Tuckerman's *Lichenes Americani Exsiccati* originally published in three volumes, the first of which appeared in 1847. The specimens of this collection, donation 676, are particularly fine and include most of the forms of the northern states known at the time.

The collection recently given by Mr. Sprague contains an admirable representation of the species of the United States belonging to seventy-five different genera. Upon the study and arrangement of this large and beautiful collection Mr. Sprague spent many years' labor. The species have all been critically examined by Prof. Tuckerman and the set includes many rare forms and some new species which are to be published by Prof. Tuckerman. Besides the numerous specimens collected by Mr. Sprague and his friends in the northern states, there are many valuable additions made by collectors in the little explored regions of Florida, Arizona, California, Washington Territory and Alaska.

The attention of the members of the Society should be called to the fact that they also owe the most valuable part of their collection of fungi to the liberality of Mr. Sprague who, not far from twenty years ago, presented a set of fungi collected by himself and his correspondents Mr. Dennis Murray, Mr. Frost and Mr. Russell in New England. The specimens had been sent to Rev. M. J. Curtis of North Carolina, the leading American authority on fungi at that date, who named the collection which included many new species. At the time of their presentation to the Society, most of the new species had not been published but they were afterwards described by Mr. Curtis in connection with the Rev. M. J. Berkeley of England, in Grevillea in 1872 and subsequent years. With the descriptions are references to the numbers attached to the species in Mr. Sprague's collection.

Mr. Scudder spoke of the arrangement of scientific libraries, advocating the decimal system of book numbering which might be modified from Mr. Dewey's classification. He gave in illustration a decimal classification for a natural history library.

General Meeting, March 3, 1886.

The President, Mr. S. H. Scudder in the chair.

Messrs. Henry Brooks, C. W. Jenks, Samuel H. Russell and Rev. R. C. Winslow were elected Associate Members.

Dr. Thomas Dwight read a paper on the significance of the internal structure of bone which will appear in the Memoirs, vol. IV, no. 1.

A life-size portrait of Mr. Alexander Agassiz, the gift of Mr. Francis Parkman was shown, for which the thanks of the Society were voted.

General Meeting, March 17, 1886.

Vice President, Mr. F. W. Putnam in the chair.

The following papers were read:

MONOGRAPH OF THE HEMEROBIDAE. PART II.

BY DR. H. A. HAGEN.

The materials for a monograph of this family were prepared long ago. After the revision of the literature published in the Stettin Entomologische Zeitung, 1851, I collected the described species in my Hemerobidarum synopsis synonymica (Stett. Ent. Zeit., 1866). Both papers antedate the time of their publication; the first was concluded about three years earlier, the second about two years. Some shorter papers followed the first: on Osmylus published in 1852; on the Hemerobidae in amber, 1856 (written in 1850); synopsis of the British Planipennes, 1858; the Ceylon Hemerobidae, 1858–59; the North American Hemerobidae 1861; on Coniopteryx, 1859; on Dilar, 1866. In my Synop. Hemer., p. 370, I stated, that a description of the genital parts would give better and more reliable characters for many species. Rambur's description of the appendages of the male of M. lutescens is the only one anterior to my synopsis. Mr. M'Lachlan, 1868, described and figured the appendages of ten species. I have figured in the meantime as many as I could, but other duties prevented their publication. The study of the previous stages so splendidly advanced by Prof. Fr. Brauer, I tried to follow in my papers on the larvae of Hemerobina (1872), Myrmeleon and Ascalaphus (1873). The study of Asa Fitch's types, of those of Brauer, Schneider and some of Zetterstedt, Erichson and others, together with my notes of types contained in other collections has induced me to publish what I know about this interesting family.

Micromus Ramb., Neur., p. 416.

Front wings with the costal space strongly narrowed at base, the transversals not furcated nor recurrent. This character is indeed the only prominent one to separate Micromus from Hemerobius; the last joint of the palpi is flat and pointed. The genitals of the male are sometimes difficult to be made out, even in alcoholic specimens. The last dorsal segment is split from below, perhaps sometimes entirely; in the cavity behind this split two superior appendages are to be seen; they are straight with the tip more or less curvate, and may reach out of the split; the last ventral segment forms a spoonshaped or elongated valve, which covers the last abdominal segment; between both segments are deeply inserted the two inferior appendages, long, spine-like and more or less curved; between these originates the long dagger-like penis, split more or less on its lower side, at least at the tip. It is very rare that all these five parts are easily visible. The females have the abdomen sloping at the apex, cut straight, with an oval opening at the end, without a visible ovipositor. The last joint of the tarsi (Ceylon species) with a large round membranous planula; as it cannot be seen in dry specimens, it may be present also in other species.

There is nothing known about the early stages of Micromus. I have not tabulated the species, as the number of the sectors of the front wing give them a very easy clew. There are seven sectors in two species, six in two, five in three, four in seven, three in one. The first four species have oblique bands cut by longitudinal ones on the front wings. The relative length of the wings and of the antennae are good characters.

There are five species known from Europe, six from North America including one from Cuba, two from Africa, four from Ceylon, two from the Pacific; of course this is probably only a small part of the actually existing species. The American species are M. montanus, M. angulatus, M. variolosus, M. insipidus, M. Cubanus, M. angustus (probably M. subanticus Walk.) all easily recognized. Only one, M. angulatus, is also found in Europe, and M. montanus much resembles European species. None of the American species seems to be common except the widely-spread M. insipidus.

1. **Micromus paganus** Linn.

Hemerobius paganus L. S. N., Ed. XII, 912, no. 11.—Villers, III, 49, no. 7.

Hemerobius marginalis (Samou.) Steph. Ill., VI, 110, no. 15.

Hemerobius elegans Goeszy, Sitzb. Wien Akad., 1852, p. 345.

Micromus lineosus Ramb., p. 416, no. 1.

Micromus paganus Schneid., Arb. Schles. Ges., 1846, p. 101.—Hag., Stett., Ent. Zeit., XIX, 130—Entom. Ann., 1858, p. 26, no. 21—Brauer, Neur. Austr., p. 58.—M'Lachl., Monogr., p. 173, no. 3, pl. IX, f. 4.—Wallengr., Monogr., p. 48, no. 1.

Long. c. al. 11–13 mm.; exp. al. 20–26 mm.

Yellowish, villous; head pale brown, front shining; palpi pale yellow; antennae half as long as wings, pale yellow, first joint and base of second brownish; occiput triangularly elevated; prothorax brown, with two transverse impressions, the first one stronger; thorax yellow; legs pale yellowish; hind tibiae very long; tip of all tarsi dark brown. Front wings large, more than twice as long as broad, tip slightly parabolic; hyaline, with a very light yellowish tinge; five sectors; gradate veins oblique, parallel; external series 9, internal 5 to 6 veins; costal space narrow at base, costals bifurcated near the costa, and the first of the costals representing almost a recurrent vein; two brown oblique bands along the graduate veins; the internal not reaching the mediana, dilated triangularly near the hind margin and sending back a crescent brown band to the base; the external interrupted before the hind margin; both bands intersected by three longitudinal ones, more or less interrupted, running to the margin behind the tip; venation white, villous, sparingly interrupted with brown; hind wings hyaline, venation white, one specimen with the external gradate brownish.

Abdomen grayish brown, whitish at its apex, with a faint median black dorsal line on the last segments; male genitals with a lower, very large and very concave lobe, seen from below oblong (in one ovoid) and very pilose; two parallel yellowish hooks originating before the base of the lobe are similar to a curved and pointed knife; the base is broader, short with a very marked dorsal knee, followed by a straight part, which ends in a strongly incurved and sharply pointed apex; abdomen of female similar, apex compressed, last segment very short, blunt.

Hab. I have before me 3 ♂ and 7 ♀; from Umeå, Lapland, locality not recorded before; from Eastern Prussia, Insterburg; from Pommerania; from Silesia, type of Schneider; Glatz; from Meseritz, Zeller, Sept. 11; from Austria, from Ischl; from Upper Karinthia, Zeller July 6. Wallengren quotes localities from southern Sweden up to Jämtland; very common in forests June to August; in England common throughout the summer, M'Lachlan; at Lyon, France, rare, Villers and Rambur; Russia, St. Petersburg, O. Sacken; Utto, Zurich, Switzerland, 2100 feet on beeches only once found, H. semireticulatus Bremi.

Though the type of Linnaeus no longer exists, and his description is very short, it has unanimously been accepted to belong to this species, first by Villers and later by Schneider. The bands on the wings variable, sometimes nearly disappearing. The specimen from St. Petersburg is the largest and most variegated seen by me.

2. **Micromus montanus** new spec.

Long. c. al., 11–12. mm.; exp. al. 21–23 mm.

I have for a long time been uncertain, if M. montanus is only a race of M. paganus; nevertheless the different shape of the genitals of the male and some additional characters have decided me to consider M. montanus as a different species.

Shape, size, color and pattern as in M. paganus. The hooks of the male are longer and much thinner, cylindrical, sharp spines, triangularly dilated at base, without the basal knee of M. paganus, but more curved before tip; the lower concave lobe more square. The occiput is not elevated; wings similar, but the internal oblique band reaching always the front margin; the gradate veins mostly darker, blackish.

Hab. Natick, Mass.; White Mts., N. H., July, 1875, Morrison. I have 2 ♂ and 5 ♀ before me.

3. Micromus angulatus.

Hemerobius angulatus Steph., Ill., vi, 106, no. 2.

Hemerobius villosus Zetterst., Ins. Lapp. p. 1050, nota (Micr.); villosus Brau., Ins. Austr., p. 58.

Hemerobius intricatus Wesm., Bull. Brux., viii, 214, 2.—Hag., Stett. Ent. Zeit. xx, 412.

Micromus intricatus Schneid., Stett. Ent. Zeit., vi, 343, no. 27.—Arbeit. Schles., Ges., 1846, p. 1.—Hag., Entom. Ann. 1858, p. 26, no. 20.—Stett. Ent. Zeit., xix, 130.

Micromus tendinosus Ramb., Neur., p. 417, no. 3.

Hemerobius lineatus Göszy, Sitzb. Wien Akad., 1852, p. 346.

Micromus aphidivorus Hag., Entom. Mon. Mag., ii, 59, no. 1.—M'Lachl., Mongr. p. 172, f. 2.—Wallengr. Monogr., p. 49, no. 2.

Long. c. al. 6–7 mm.; exp. 12–16 mm.

Rufous-brown; front shining; palpi brownish; vertex slightly carinated; antennae yellowish, the two basal joints darker brownish, the other sometimes darker annulated; thorax brown; legs yellow, the four anterior tibiae with two indistinct blackish bands, extreme tip of tarsi darker; front wings about half as broad as long; apex elliptical; slightly pubescent, luteous-hyaline, faintly mottled with brown spots; crossed with three oblique about equidistant very narrow brown fasciae, which are intersected by three similar longitudinal fasciae; the venation is luteous, interrupted with fuscous; along the margin are dark fuscous forks and spots; four to five sectors; seven veins in the apical gradate series; six in the inner one; hind wings pale, more hyaline, some darker blackish veins along the front and apical margin. Abdomen dark brown; male with a yellow spoon-shaped ventral valve; the last dorsal segment paler, truncate, split from below two-thirds of its length: out of the split two processes reach more or less, viewed from the side straight, from above with the apex bent inside; this apex is black, sharp, the convex part cut horizontally; both processes together represent a kind of forceps, in which the bent-up apex of the penis is placed; the penis is long and narrow, gradually enlarged to base, tip split below (or bifid?) two longer divergent straight spines above the lower valve, originating near the base of penis. Female with the end of abdomen blunt, pale.

Hab. There are sixteen specimens before me; one ♂ from the

White Mts., Morrison; two from Canada, J. Jack; another from Europe; ♂ ♀ from Sweden, Mus. Lund. types of H. villosus, Zett.; ♂ ♀ from St. Petersburg, August, O. Sacken; from Koenigsberg, E. Prussia, July; from Silesia, May 6, type of H. intricatus Schneid.; from Pommerania; from Hambourg; from Zurich, Switzerland, very common in pine forests, sent by Bremi as H. aphidivorus Schrk.; one ♂ from Syracuse, Sicily, April 1844, Zeller, the type described by Schneider; I have seen a large number, the types of Wesmael, Rambur, and from Madeira, Wollaston.

Stett., Ent. Zeit. XIX, 130, no. 2. I have quoted specimens from S. Russia and Irkutzk, Siberia. Both are no longer in my collection; but I have reason to doubt the determination of the specimen from Irkutzk; after Zetterstedt and Wallengren, M. angulatus is widely distributed in Sweden, but always rare, July to September. In England, M'Lachlan, very rare, but widely distributed in summer. In France, Rambur, common everywhere; also in Sardinia; in Belgium near Bruxelles; in Austria, Brauer, near Vienna, rare.

After a careful examination of Schrank's description Fn. Austr. p. 313, no. 627, and the more detailed in Fuesly N. Mag. I, 283, I am convinced that his H. aphidivorus is not this species but probably H. marginatus. I have adopted in my synopsis on Bremi's authority and only in the Madeira Neur. Schrank's name. Brauer and Schneider have never adopted it, but M'Lachlan and Wallengren, perhaps on my authority. In my manuscript notes on Stephens' species, I had H. angulatus determined as H. aphidivorus and as M'Lachlan gives the same determination, the name of Stephens has to be restored.

The North American specimens are doubtless identical with the European species. M. angulatus, though much smaller, imitates M. paganus in the bands of the front wings.

4. **Micromus meridionalis** Costa.

Mucropalpus meridionalis Costa, Nnov. studii Ent. Calabr. ult. p. 31, pl. III, f. 6 (not compared by me).

Costa Fauna Nap. Neurot. Supl. 2, pl. XIII, f. 2.

Costa has in both papers referred his species to Mucropalpus, but the narrow base of the costal space unites it to Micromus. The circumstance that it was collected in the valley of Aspromonte, the most southern part of Calabria, combined with the fact that Zeller collected M. angulatus in Syracuse, Sicily, is in favor of the identity of Costa's species. The figure is too yellow, but it contradicts not the supposition, and the description contains nothing which would not apply to M. angulatus. The intersecting longitudinal bands of the front wings are not mentioned, but they are often very faint. Costa's specimen and Schneider's have only four sectors. Till the contrary is proved, the identity can be accepted. Brauer, Neur. Europ., p. 29, also refers Costa's species to Micromus.

5. Micromus navigatorum.

Micromus navigatorum Brauer, Wien. Z. B. Ges. XVII, 508.

Long. corp., 5 mm.; exp. al., 15 mm.; long. al. ant., 7 mm.; al. post., 5 mm.

Unknown to me; description of Dr. Brauer:—grayish ochreous; antennae same color, with paler villosity; prothorax with two pairs of dark spots; legs pale; wings hyaline; front wings ochreous with transverse nebulous fasciae; gradate veins blackish-brown, fumose around. Both series very oblique, parallel with eight external and six internal veins; other veins pale ochreous, alternately brown; seven sectors; a small brown spot in the basal third; five to six fumose spots on the hind margin; hind wings hyaline, veins ochreous; seven external black gradate veins, four internals; five sectors.

Hab. Ovalau, Viti, and Upolu, Samoa, coll. Dr. Graefe. This species somewhat resembles M. angulatus (Brauer), but seems so near M. timidus, that a more detailed description is needed to separate the two species.

6. Micromus variegatus.

Hemerobius variegatus F., Ent. Syst., II, 85, no. 18.—Steph., Illustr., VI, 113, no. 25.—Burm., Hdb., II, 974, no. 2.—Wesm., Bull. Brux., III, 214, no. 1.

Micromus variegatus Ramb., Neur. p. 417, no. 2.—Schneider, Arb., Schles. Ges. 1846, p. 100.—Brau., Neur. Austr., 58.—Costa, Fn. Nap. Neur. Hemer., p. 4, pl. 10, f. 2.—Hagen, Stett. Ent. Zeit., XXI, 54, no. 1.—Entom. Ann. 1858, p. 26, no. 19.—M'Lachlan, Monogr., 172, no. 1, pl. IX, f. 4.—Wallengren, Monogr., 50, no. 3.

Long. c. al. 6–8 mm.; exp. al. 12–16 mm.

Body black; villosity white; front, shining coal black, on the occiput three longitudinal marks; palpi grayish; antennae yellow, long, more than three-fourths of the front wing, basal joint blackish, the other faintly annulated with a darker hue; thorax, dull, with some brown marks; legs yellowish white, whitish villous, tibia with a blackish ring near the knee and another on the apex; last tarsal joint, dark brown; claws pale; front wings narrow, long, three times longer than broad, apex rounded, hyaline, veins white and brown, whitish villous; the wings are somewhat irregularly spotted with brown bands sometimes along the gradate veins, a regular series of spots along the margin, the forks on apex of wing, the gradate veins; three sectors; the two gradate series not parallel, the external one somewhat irregular; five veins in each series; hind wings with three irregular fumose blotches, on the apex of the wing and on both margins before the apex, where also the veins are blackish; abdomen black, last segment pale whitish; a spoonshaped ventral valve; two yellow, sharp, subulate appendages; last dorsal segment flat, split from below for three-fourths of its length; female with a compressed, triangular apex.

Hab. Europe, 20 specimens, half males, before me: Silesia, the types of Dr. Schneider; Vienna, Austria, Mayr; Hamburg, Winthem; Stuttgart, Zenneck; Regensburg, Herrich Schaeffer; Switzerland, Zurich, Bremi and Imhoff; Bex, Dr. Hensche; England F. Walker.

Wallengren, Sweden, June and July in southern and middle provinces, rare; England, M'Lachlan, frequent in summer and generally distributed; Italy and Sardinia, A. Costa; Sardinia, Rambur; Corsica, Hagen.

The females are commonly larger; the appendages of the male are not easily seen; the spoonshaped lower valve and the two subulate spines are certain; also the flattened dorsal segment split from below (not two oval valves above), but I have not been able to see upper appendages, and only doubtfully distinguish a straight penis.

Wallengren is surely right in stating that H. variegatus Zett.

belongs to another species. My specimen from England ♂ is very small face pale brown, only two sectors.

Mr. E. Newman, Proc. Ent. Soc., May 5, 1856 (repr. Zoologist, p. 5152) states that Mr. Dorville found in a pupa shell of Abraxes grossularia a white silken cocoon, out of which emerged H. variegatus. This is the only fact known of the previous stages of Micromus. When I saw Stephens' collection, a specimen of H. variegatus with the label fimbriatus was near the type of H. hirtus, but other types of H. variegatus were in the right place and no. 26 H. fimbriatus in the Illustr. with a ?, was wanting.

7. **Micromus variolosus**, n. spec.

Micromus variolosus Hag.

Long. c. al. 7. mm.; exp. al. 13 mm.

This species imitates M. variegatus.

Head and thorax brownish gray, with a little bluish tinge, with transverse rows of very small black tubercles; head in front and near the eyes, yellow, glossy; palpi blackish, shining; antennae shorter, half as long as the front wings, yellow, the two basal joints blackish, but the first yellow above; thorax with yellowish sutures. Front wings long, narrow, more than three times longer than broad, very little dilated in middle, apex elliptical; hyaline, milk-white, mottled with numerous blackish spots, very shortly fringed around and on the veins with white cilia; four sectors; series of gradate veins irregular, the external with six gradate, the internal with four; all cells between them very elongate and narrowed to the gradate veins; a maculose dark band somewhat longitudinal along the external gradate series, numerous other more or less definite spots; some darker, along the hind margin, some transverse near the base; veins brown regularly intersected with white; hind wings of similar shape, hyaline, with a few darker spots on the apical half of the front margin; veins on the basal half white, brown on the apical half with some white intersections; three sectors, four to five external brown gradate veins and five internals; cells very large. Legs yellowish white, whitish pilose; two black bands on tibia, one on femur, the last tarsal joint black, claws white. Abdomen blackish brown, the side membrane and the last segment luteous yellow; tubercles large; last ventral segment cut straight; the last segment compressed but split;

though no appendages are produced the specimen must be a male.

Hab. Only one specimen from Denver, Colorado.

It is a remarkable fact, that the three prominent species of Europe are represented in N. America; one of them M. angulatus is perfectly identical with the N. American species; the second, M. paganus, is so very near M. montanus, that only the appendages of the male show a sure structural difference; if a similar variation can be shown in European specimens, M. montanus would have to be considered as a race of M. paganus. The third, M. variegatus, differs somewhat more from the N. American species, of which only one specimen is known. One of the most striking characters of M. variegatus (in 19 specimens before me) the coal black glossy face is not mentioned by M'Lachlan and Wallengren, and Stephens, Ill., says also, deep fuscous, head very glossy in front. The only English specimen before me, though apparently young, has also the front brownish. It is desirable to know if the English and Swedish specimens never have a black face. But I believe that M. variolosus shows more differences. The antennae are shorter, the first joint yellow above; the small black tubercles on head and thorax are not to be found on twenty European specimens; the wings are narrower, and the venation shows more elongated cells. There are more American specimens needed and the knowledge of the male appendages to make this species beyond doubt. At all events it differs much more from M. variegatus than M. montanus does from its European relative.

8. Micromus insipidus.

Micromus insipidus ♀ Hag., Syn. N. Am. Neur., p. 199, no. 4.
Micromus sobrius ♂ Hag., ibid, 199, no. 5.

Long. c. al. 7 to 10 mm.; exp. al. 14 to 18 mm.

Head fuscous, with some pale villosity; front paler, luteous; palpi pale; antennae yellow, the two basal joints marked with fuscous; thorax and abdomen fuscous; legs pale, four anterior tibiae with two fuscous rings; tarsi yellowish; front wings slightly pilose, less than three times as long as broad, apex elliptical; hyaline, very little fumose, densely mottled with fuscous spots, forming in the apical half and along the hind border some waved, maculose, transverse bands; veins pilose, pale, with many fuscous interruptions; four sectors; series of dark, gradate veins, oblique, about parallel; six external gradate, of which the second is nearer to the apex than the first; four internal gradate; hind wings hyaline, veins pale, with six and four gradate series, the external often blackish; last segment of male yellowish, above the spoon-shaped ventral valve two long, brownish, sharp, flat spines, excised largely externally on tip; a pale, small penis between them curved upwards and somewhat inflated just before the tip; dorsal segment split from below nearly to the top; two small darker appendages with the tip a little incurved are seen very near together in the interior of the dorsal segment; apex of the female abdomen blunt, pale.

Hab. I have 15 specimens (4 ♂) before me from Philadelphia; New York, West Point; Massachusetts, Cambridge, Beverly, Provincetown, July 21; Rock Island, J. W. Walsh; from Upper Wisconsin River, Kennicott; from Morganton, North Carolina, Morrison.

Mr. M'Lachlan suggests, Journ. Linn. Soc., IX, 274, that M. insipidus may be H. posticus Walker. Indeed, the description agrees, but it is placed among the species with three sectors, and besides I have compared in London my type of M. insipidus with Walker's species, and noted nothing about the identity. Of the two types from Georgia of H. posticus, one has four sectors and seven and five gradate veins; the other has three sectors and six and three gradate veins; I presumed the latter one to be H. posticus type.

M. insipidus is not among the types of A. Fitch.

Micromus sobrius Hag., Syn., p. 199, no. 5, should be better united with M. insipidus. When I described those species I had of M. sobrius, only two males, of M. insipidus, only two females, before me, which are still in the collection. Now I find no reliable difference between the two species. The appendages of the males are not well known except for the spines, and even those are not easy to be seen.

9. **Micromus Cubanus** n. sp.

Micromus Cubanus Hag.

Long. c. al. 8 mm.; exp. al. 14 mm.

Similar to the smaller specimens of M. insipidus. The tibiae have two black spots; the front wings are not mottled with brown on the membrane, but all veins are alternately yellow and dark brown; five sectors; external gradate veins seven; internal four.

M. insipidus has the external gradate longer, and always the second more remote to the apex of the wing. M. Cubanus has the second in the same line with one to four, which form a vertical line and not an oblique one as in M. insipidus; the external gradates are deep black; abdomen yellow; only the sharp inferior spines are to be seen, their tips longer than the valve; but I am not able to see that the spines are dilated before the apex as in M. insipidus; the upper valve is split from below.

Hab. Cuba; one ♂ from Gundlach, no. $\frac{93}{11}$ of his catalogue.

I would not have separated this species, but the lack of mottled brown on the front wings, the five sectors and the external gradates which are deep black, vertical in the beginning, the yellow abdomen and the not dilated spines seem to be characters sufficient for the separation.

10. **Micromus angustus** n. sp.

Micromus angustus Hag.

Long. c. al. 7 mm.; exp. al. 13 mm.

Head and prothorax yellowish with white villosity, with brownish spots above in older specimens; palpi pale, last joint blackish, somewhat dilated; antennae yellow, half as long as the wings; legs pale, whitish. Abdomen dark grayish brown; all specimens seem to be males; the genitals are not to be seen; a short, leaf-shaped ventral process is to be seen; in one specimen what seems to be the tip of the penis is a little prominent. Wings long, narrow, nearly four times as long as broad, apex elliptical; hyaline, a little fumose; veins alternately yellow and black, the gradate veins, the base of the sectors, some little spots around the margin and a more visible one in the middle of the wing nearer to the basis black; four sectors; five irregular gradate veins in the external series, four in the internal; hind wings similar in length and size, hyaline, veins yellowish, four external gradate cells larger.

Hab. Haulover, Florida, 2, March 2 and 4; Capron, Florida, 2, April 14 and 25, both from H. G. Hubbard; Morganton, North Carolina, 2 from Mr. Morrison.

This small, narrow species can not be confounded with other North American forms; the older ones are darker, also the veins in the hind wings. It is near M. linearis from Ceylon.

Perhaps this is the Hemerobius subanticus Walk., Neur. Br. Mus., p. 282, no. 13. The darker specimens do not disagree with the description, but H. subanticus is said to have only three sectors. The type in the British Museum of this species will decide the question; among my notes made in London I find H. subanticus is a Micromus with very narrow wings.

11. Micromus calidus.

Micromus calidus Hag., Wien. Z. B. Ges., IX, 207, no. 126.

Long c. al. 8 mm.; exp. al. 14 mm.

Brownish black with pale villosity; head above black, densely villous, occiput somewhat elevated; front glossy pale with transverse maculose brown bands; between the antennae black; the two basal joints of antennae black, the following brownish, the apical third blackish brown, shortly villous; palpi pale; prothorax black with two globular tubercles near the base; mesothorax black; legs whitish, pilose; four anterior on femur and tibia with three blackish rings, one basal, one apical and one in middle; last tarsal joint and claws dark; front wings short, nearly half as broad as long, apex elliptical; hyaline, grayish-fumose, part between the gradate series and at the base near the hind margin paler, whitish, faintly mottled with gray on the posterior half; veins blackish-brown, strongly interrupted with white, also on the front margin; six sectors black at base; three faint transversals on the tip of the subcostal space; external series with nine black gradate veins, the uppermost placed more internally; inner series with five black gradate; both series parallel except in the anterior third; at the base a short maculose black stripe; hind wings hyaline, grayish-fumose, veins pale, pterostigma part transversally blackish; external series with eight black gradate, also their forks dark; internal series with five gradate; abdomen dark brown, last segment luteous; two straight short spines above the lower valve of the male and a dagger-like spine between the superior valves, perhaps the penis.

Hab. Ceylon, Rainbodde, Nietner.

In the last lot received from Rainbodde by Mr. Nietner were three specimens in alcohol. One female belongs to M. australis. Another female is doubtful, entirely yellow and the wings pale, yellow in the pterostigmatical part, veins yellow, the beginning of the sectors, the gradate veins and some near the margins brown; one front wing with six sectors has the venation of M. calidus; the other wing has an abnormal reticulation. The yellow prothorax has a brown line on each side. I would have referred it to M. calidus, but the legs have no black rings and on the wings the much variegated pattern of M. calidus is also wanting. The male is smaller, body brown, antennae annulated with brown; wings pale with five sectors and seven gradate veins in the external series; abdomen dark brown, genital appendages not to be seen; legs without black rings. All tarsi have a large, thin orbicular plantula, exceeding the claws on both sides.

12. Micromus australis.

Micromus australis Hag., Wien, Z. B. Ges. VIII, 483, no. 76.

Long. c. al. 7 mm.; exp. al. 12½ to 15 mm.

Pale luteous, luteo-pilose; head, palpi, antennae, pale luteous; occiput transversely elevated; prothorax nearly smooth, on each side a large brownish ill-defined spot; legs pale. Front wings less than half as broad as long, hyaline with a yellowish tinge, margins and veins luteo-pilose; veins luteous except the gradate and the veins connected with them, which are dark brown; four sectors, nine gradate in the external series, five in the internal; the series not strictly parallel; hind wings similar in shape and color; external gradate eight; internal five, both brown. Abdomen luteous, very pilose; last segment of male paler; lower valve long, narrow; rounded tip a little larger with numerous very long, spine-like hairs; the valve split above; at the base of the valve the two lower appendages are flat, erected, at tip lancet-shaped, recurved, sharply pointed, serrated on both margins; superior valves separated, ovoid, convex, on the lower margin with a short strong hook and some short pyramidal spines; apex of the female truncated.

Hab. Ceylon, Rainbodde, by Nietner. Eight males and females before me.

13. Micromus linearis.

Micromus linearis Hag. Wien, Z. B. Ges. VIII, 483, no. 75.

Long. c. al. 8 mm.; exp. al. 14 mm.

Elongate, luteous, occiput, tuberculate; antennae luteous; palpi and legs pale; prothorax anteriorly with two impressions; wings long, narrow, about four times as long as broad, narrowed at base, apex elliptical; hyaline with a yellowish tinge, or subfumose; veins pale, alternately blackish; two black marks on the pterostigma, several smaller ones on the hind margin; the base of sectors and of some forks blackish; four sectors; six external gradate, five internal, not strictly parallel, the externals somewhat irregular; margins pilose; hind wings similar, pale, a blackish tinge on the apex of the subcostal space. Abdomen, blackish; of the male genitals only the closed valves are to be seen.

Hab. Ceylon, Negombo and Rainbodde, by Nietner; 30 ♂, 1 ♀.

14. Micromus costulatus.

Micromus? costulatus Motsch., Bull. Moscou, xxxvi, 2, 10.

Micromus linearis Hag., var? minor. Wein, Z. B. Ges. viii, 483, no. 75.

Long. corp. 5 mm.; exp. al. 8½ mm.

Only a fragment; thorax and legs pale; wings less than three times longer than broad, hyaline, veins pale, the gradate and some forks dark; four sectors, six and five gradate veins; hind wings similar. Motschulsky's description is as follows: Sordide albescens, transversim fusco variegatus, sparsim testaceo-ciliatus; occipite subelevato; thorace medio longitudinaliter subconvexo, utrinque infuscato; alis elongatis, venis crassiusculis, subelevatis, fere costatis, fusco annulatis, serie externa sex, interna quinque gradata, pedibus testaceis. Long. 1¾ lin.; exp. alar. 3½ lin.

Hab. My specimen Ceylon, Rainbodde, Nietner; Motschulsky's, Ceylon, Mt. Patannas, Nietner. The identity of both is very probable; but the dimensions of the latter are a little smaller.

15. Micromus pumilio.

Micromus pumilio Stein, Berl. Ent. Zeit., vii, 419, no. 40—Brau. Neur. Europ., p. 29.

Long. corp. 2½ mm.; exp. al. 9 mm.; long. al. ant. 4 mm.

Translation of Stein's description: Testaceus, palpis maxillaribus abdomineque fuscis.

Near H. dipterus. Head, antennae, thorax below and legs whitish yellow; the twelve basal joints of antennae, the first excepted, annulated with brown; maxillary palpi dark brown; eyes large and prominent, so that the prothorax looks very coarctated; it has brownish spots besides; wings grayish white, veins brownish, some transversals brown, but all less strong than by H. dipterus; wings twice as long as abdomen; hind wings a little shorter; tibiae fusiform.

Hab. Greece from Krueper, now in the Museum of Berlin.

Dr. Fr. Stein, in 1863, had the kindness to send to me all his Neuroptera from Greece for determination. As Stein was at this time the only possessor of an excellent pair of H. dipterus, now in the Museum of Berlin, I asked him to compare the species from Greece with H. dipterus. He answered (Nov. 20, 1863) that Micromus pamilio is distinctly different, if both species are compared, in the colors of the head and antennae, and in the venation.

I have, therefore, no doubt that M. pumilio is a good species, Brauer, l. c., has quoted it with a ? under H. dipterus.

16. Micromus Tasmaniae.

Hemerobius Tasmaniae Walker, Trans. Ent. Soc. Lond., ser. 2, v, 186—M'Lachl., Ann. Mag. N. H., July, 1873, p. 39.

Long. corp. 5 mm.; exp. al. 14 mm.

(Walker's description.)

Mas. et fem.—Testaces, capite fulvo, fascia vitta punctisque duobus testaceis, thorace lituris fulvis, pedibus albidis, alis angustis subvitreis, venis albidis, alis anticis subpubescentibus, venis paucis fuscopunctatis.

Male and female. Testaceous; head tawny with a band, a stripe and two points testaceous; thorax with some tawny marks; legs whitish; wings narrow, almost vitreous; veins whitish; fore wings minutely pubescent; few veins, with brown points.

Hab. Tasmania; coll. W. W. Saunders, now in the Brit. Museum. I saw the species years ago in Mr. Saunders' collection, but have no specimen before me.

Mr. M'Lachlan, Ent. M. Mag. vi, 27, says: H. Tasmaniae Walker is a Micromus; I have seen it from several parts of New Holland, and possess two individuals from New Zealand, which differ only in the rather greater amount of spotting on the veins, and with these more strongly ciliated; a comparison of an extensive series from both quarters will be requisite to prove the identity or distinctness of the two forms.

17. Micromus timidus.

Micromus timidus Hag., Bericht., Akad. Berlin, 1853, p. 481. Hag., Peter's Reise Mossamb., v, 91–92, pl. 5, fig. 2.

Long corp. 8 mm.; exp. al. 15 mm.

Brown, whitish pilose; face glossy; vertex elevate; palpi brownish; antennae reaching the middle of the wings, pale yellow, the two basal joints and the ten apicals brown; legs pale yellow; apical half of abdomen wanting; front wings hyaline, subcinereous, base and hind margin mottled with gray; veins and villosity pale yellowish; seven sectors; series of gradate veins parallel, external with eleven, internal with seven veins; sectors at the base and throughout spotted with brown; gradate veins and their connections dark brown; hind wings hyaline with nine external and six internal gradate veins; the internals and connections dark brown.

Hab. Mozambique, Peters; the type in the Berlin Museum.

As the venation was drawn by me with the camera, its correctness is without any doubt. In the older description eight sectors were stated, but I had then wrongly counted the basal branch, which does not belong to the sectors.

18. Micromus insularis, n. sp.

Micromus insularis Hag.

Long. c. al. 8 mm.; exp. al. 15 mm.

I had before united this species with M. timidus, even after comparing it with the type in the Berlin Museum, but the venation differs so much that I think they cannot belong together. Front wings with six sectors; series of gradate veins parallel, eight external veins, five internals. Otherwise the coloration is identical. The specimen is a male; lower appendages yellow, brown on tip, long, cylindrical, turned outside, a little curved at the base; a pointed penis in the split; the abdomen is brown, the last segment yellowish.

Hab. Madagascar, one specimen presented to me by C. A. Dohrn. More specimens of both species are needed to prove their position.

NORTH AMERICAN SPECIES OF THALICTRUM.

BY WILLIAM TRELEASE.

Thalictrum is not a large genus. Bentham and Hooker[1] recognize about fifty species, which Lecoyer[2] increases to sixty-nine, twelve of which are attributed to the United States. Watson[3] enumerates fourteen coming within our limits. Though our species are few, they are by no means easily recognized, so that I gladly availed myself of the invitation of Professor Gray to study the numerous specimens contained in his herbarium. Through his kindness these have been supplemented by those in the herbarium of Columbia College, including the collections of Torrey and Chapman, for which we are indebted to Mr. Britton, and the admirable specimens of J. Donnell Smith of Baltimore and W. M. Canby of Wilmington, Del. It has also been my privilege to examine the American species in the herbarium of Wellesley College, shown me by Miss Hallowell, in the Lapham herbarium of the University of Wisconsin, loaned by Mr. Seymour, and in the herbarium of this Society, placed at my disposal by Miss Carter; and a number of friends have kindly allowed me to examine their specimens of our eastern forms.[4] At the suggestion of Dr. Gray, I have ventured to bring the results of this study together in the following pages. The nomenclature adopted is, in the main, that of his manuscript revision of the genus for the Synoptical Flora, which he has obligingly placed in my hands, so that I shall not enter into the discussion of this question, merely citing such synonyms as are necessary for an understanding of the more perplexing species. The principal bibliography of the genus is indicated in Watson's Index, already referred to.

Excluding T. anemonoides, which is now removed to Anemonella, as proposed by Spach,[5] the genus is characterized as follows:— Perennial plants with alternate, ternately decompound leaves, none of them collected into an involucre. Flowers panicled or rarely racemed, apetalous, perfect, diœcious or occasionally poly-

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[1] Genera Plantarum, I, 1872, 4.

[2] Monographie du genre Thalictrum, Gand., 1885. (From Bull. Soc. Roy. de Bot. de Belg., 1885–6.)

[3] Bibliographical Index to North American Botany, 25.

[4] Since the presentation of this paper, I have examined the specimens in the Engelmann herbarium, but without gaining any additional points.

[5] Gray: Bot. Gazette, 1886, XI, 39.

gamous. Sepals 4–5, petaloid in some species; stamens indefinite; carpels numerous (rarely few), inserted on a small receptacle; ovule solitary, pendulous; stigma unilateral; achenia tailless, marked on each side with a few nerves, ribs or deep grooves, terete or compressed, rarely inflated or (in some European species) subtriquetrous.—Benth. & Hook., Gen. Plant., I, 4.

In distinguishing the species, the most valuable characters are drawn from the condition of the flowers,—whether perfect, polygamo-diœcious, *i. e.*, diœcious but regularly with a limited number of stamens in the flowers of some fertile plants (less commonly with abortive? pistils in staminate flowers), or diœcious; the length and form of the filaments, which vary from filiform with a slight widening toward the anther to narrowly, or, in T. clavatum, broadly and abruptly spatulate, and of the anthers, which are ellip-

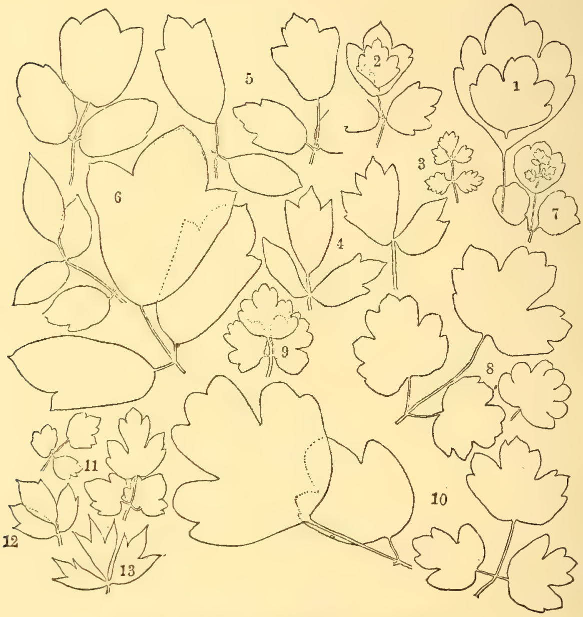

FIG. 1. FOLIAGE OF THALICTRUM.

1. *T. clavatum.* 2. *T. sparsiflorum.* 3. *T. alpinum.* 4. *T. minus.* 5. *T. polygamum.* 6. *T. purpurascens.* 7. *T. debile;* the smaller leaflets from var. *Texanum.* 8. *T. dioicum.* 9. *T. venulosum.* 10. *T. occidentale.* 11. *T. Fendleri.* 12. *T. Fendleri,* var. *Wrightii.* 13. *T. polycarpum.*—Reduced one-half.

tical, oblong or linear, pointless, mucronate or with a (usually thin and flat) cuspidate prolongation of the connective; and the character of the achenia, which are sub-sessile or stipitate, papery or thick-walled, terete, somewhat two-edged or compressed, grooved, ribbed or with free or anastomosing veins, and either nearly pointless or prolonged into a beak, bearing the remains of the stigma.

The foliage is not readily described so as to be of value, and is subject to considerable variation in most species, but it is sometimes characteristic to the eye, as the texture and surface of the leaflets and the form and disposition of their lobes yield good characters. The form and margin of the dilated base of the petiole, which in some cases is more or less free and stipuloid, and the presence or absence of stipels to the leaflets cannot, apparently, be depended on for the discrimination of species.

The plants are usually glabrous or glaucous, but vary a great deal in this respect. When not pubescent, the lower surface of the leaflets not infrequently appears finely granular under a lens, from the prolongation of the apices of the epidermal cells into blunt, thick-walled papillæ (fig. 2, 1). With these granulations, are associated, in several species, straight, cylindrical hairs (flattened and ribbon-like only when dry), consisting of a single row of elongated cells (fig. 2, 2). These are most abundant on the lower surface of the leaflets, on the pedicels, achenia, etc., and, especially, at the base and forks of the petioles. In other cases the same parts are more or less densely covered by unicellular, glandular hairs (fig. 2, 3), with or without interspersed papillæ. These two

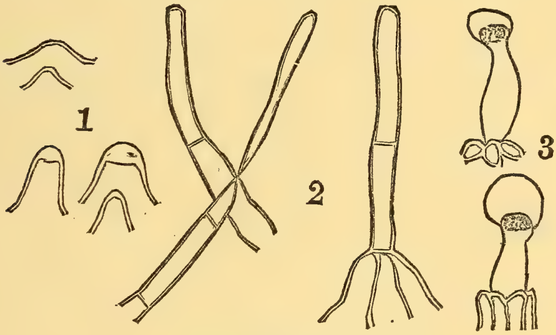

FIG. 2. TRICHOMES OF THALICTRUM.
1. *T. Fendleri*, var. *Wrightii*. 2–3. *T. purpurascens*, — magnified.

forms of trichomes do not appear to occur on the same plant, though within the limits of a species both may be found on different individuals. Commonly the groups of cells about the base of a trichome protrude, especially on the glandular plants, so that it may appear to rise from a stout multicellular papilla that is characteristically much developed in some species which do not occur in the United States. These papillæ, when numerous, give a scurfy appearance to the lower surface of the leaflets, especially along the veins.

The stigmas differ much in different groups, but what might be taken as type-forms are connected by intermediate gradations, and in related species they are so uniform as to be of little value for purposes of discrimination. In most species the stigma is sagittately dilated at the base and more or less elongated, being very long in a southern form of T. purpurascens, while in T. minus, etc., it approaches the deltoid form characteristic of certain other European species. In T. clavatum it departs from this type, being short and rounded, yet decidedly oblique or lateral on the short style so that it still differs essentially from the depressed-globular but truly terminal stigma of Anemonella.

Our Thalictrums show less adaptive differentiation connected with their pollination than many genera, but they are still instructive. The typical flowers of Ranunculaceæ are of simple structure like those of Ranunculus, Anemone, etc., but possess petals or petaloid sepals and are adapted to pollination by short-tongued insects such as flies, small bees, etc.[1] Sometimes the only attraction for these insects is pollen, which is advertised by the coloration of the floral envelopes or stamens, rarely accompanied (Anemone Hepatica) by slight fragrance; but in other instances nectar is present, secreted by either of the floral organs (sepals, Paeonia;[2] petals, Ranunculus, etc.; stamens, Atragene, Pulsatilla; pistils, Caltha), and advertised similarly to the pollen. This type is modified in two directions; in one reaching the complexity of Delphinium and Aconitum, which have highly specialized entomophilous flowers, and in the other becoming more and more simple, finally reaching a purely anemophilous state in most species of Thalictrum.

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[1] For the principal literature of the subject see H. Müller, Befruchtung der Blumen, Fertilization of Flowers, and Alpenblumen: and Grant Allen, Colours of Flowers.

[2] In which genus the external glands are to be regarded as protective.

Thalictrum petaloideum and other foreign species are as markedly entomophilous as Anemonella and Anemone. Of our own species, T. clavatum and T. sparsiflorum are unquestionably adapted to insect-pollination. The former has small stigmas, included stamens, small anthers and relatively conspicuous flowers. The latter, with inconspicuous flowers and longer filaments and stigmas, approaches an anemophilous condition that is intensified in T. polygamum, which has dilated, rigid and conspicuous filaments and short anthers, but more numerous stamens and large stigmas, so that it is adapted to either insect- or wind-pollination. T. purpurascens, with more strictly diœcious flowers (those of the fertile plants, therefore, less ornate, and rarely tempting insects by a provision of pollen), longer and more flexuous stamens and larger anthers, with a superabundance of pollen, departs still more from the entomophilous type, and is apparently mainly dependent upon the wind. Our other species appear to be exclusively anemophilous. Connected with these floral differences, a difference in the pollen of the extreme forms might have been expected, but the examination of dried specimens shows that no such difference exists, the pollen grains of all being nearly globose and smooth, and differing only to a limited extent in the unimportant character of size. Persons who have the opportunity should observe whether all of our hermaphrodite species are protogynous, as T. minus is said to be by Müller.[1]

It is interesting to note in connection with the prevalence of anemophilous and diœcious flowers, that our species are all endemic except T. alpinum, which, like many arctic-alpine species, occurs on both continents ; T. minus, a European and Siberian species, one variety of which has barely reached the new world by way of N. E. Asia ; and T. sparsiflorum, which, reaching this continent in the same way, has extended southward in the mountains, like the first.

The following arrangement of the species which belong to the Flora of North America shows their essential characters, and, to a certain extent, their relationship :—

* Flowers all perfect.

Stigma minute ; filaments short, broad and petaloid above,
—*T. clavatum*.

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[1] Fert. of Flowers, 71.

Stigma more or less elongated ; filaments not petaloid.
With slender root-stocks ; stem simple, scapiform or 1-leaved, —*T. alpinum.*
Without root-stocks ; stem branched and leafy.
Achenia flattened, oblique, low-nerved ; anthers elliptical, pointless, ... — *T. sparsiflorum.*
Achenia sub-terete, ribbed ; anthers oblong, mucronate, — *T. minus.*

* * Flowers polygamo-diœcious.

Perfect flowers few ; filaments spreading, not wider than the linear-oblong, cuspidate anthers, . . . —*T. purpurascens.*
Fertile flowers usually with stamens ; filaments erect, spatulately much widened ; anthers oval, blunt or barely mucronate ; foliage not glandular, ...—*T. polygamum.*

* * * Flowers diœcious (except in monstrosities).

Achenia usually thick-walled, not greatly flattened, filled by the seed ; foliage glabrous.
Leaflets very thin ; fruit terete.
Stem weak, reclining ; roots tuberous, . — *T. debile.*
Stem firmer, erect ; roots coarse, fibrous, — *T. dioicum.*
Leaflets firmer, veiny below ; fruit somewhat 2-edged, — *T. venulosum.*
Achenia thin-walled, 2-edged, flattened or turgid.
Leaflets very thin ; fruit lanceolate or fusiform, scarcely oblique, ... — *T. occidentale.*
Leaflets firmer ; fruit broad, obliquely oval or obovoid.
Achenia few, not reflexed ; their principal nerves parallel or occasionally reticulated, . —*T. Fendleri.*
Achenia numerous, forming a dense cluster, the outermost reflexed ; with mostly free-branching veins, — *T. polycarpum.*

1. T. CLAVATUM, D C. Reg. Veg. Syst. Nat. I, 171. — Glabrous. Stem slender but not decumbent, 6–18 inches high, sparingly branched and leafy above. Leaves ample, biternate, sessile except the lowermost. Leaflets thin, remote, rather large ($\frac{1}{2}$–1$\frac{1}{2}$ in. long and $\frac{3}{8}$–1$\frac{1}{2}$ in. wide), roundish, oval or obovate-cuneate, with mostly three rounded apical lobes that are often again similarly lobed, the sinuses rounded at bottom ; ultimate petioles equalling or shorter than the smooth or slightly granular blade. Flowers

perfect, of medium size, erect in a few-flowered cyme. Sepals white, petaloid, spatulate-obovate, soon reflexed. Stamens numerous, scarcely exceeding the sepals, filiform below but spatulately enlarged and petaloid (not clavate), above, bearing oval, blunt anthers $\frac{1}{2}$ mm. long. Achenia (often red-tinted) 5–10, 4 mm. long, spreading on reflexed or filiform stipes of equal length ; flattened, with the ventral suture mostly concave and the dorsal regularly arched ; marked with about eight low, longitudinal nerves that are often forked or anastomosing. Stigma minute, rounded, oblique on the short style.—Mountains, Virginia to Alabama.

Hooker confounded the western T. sparsiflorum with this species, his error leading to the establishment of T. filipes by Torrey and Gray. T. nudicaule, Schw. is found by Dr. Gray to be only a few-flowered, nearly leafless form of this species.

2. T. ALPINUM, L. Sp. Pl. 767. — With scaly root-stocks, the leaves tufted at their summits. Stem naked or 1-leaved near the base, very slender, 1–10 inches high, glabrous or sparsely glandular above. Leaves small, long-petioled, biternate, glabrous. Leaflets approximated, sessile, thick and firm, dark-green above, very pale and glaucous below and with prominent veins ; orbicular-cuneate, $\frac{1}{8}$–$\frac{1}{4}$ in. long, short-lobed at the apex, with revolute margins. Flowers small, perfect, nodding on slender pedicels, racemed. Bracts scale-like or with a lanceolate, obovate apical lobe. Sepals inconspicuous. Stamens about ten, their purplish filaments short but slender ; anthers oblong, mucronate, 2 mm. long. Achenia 4–5, 3 mm. long, subsessile, obliquely fusiform or obovoid, subterete with about ten longitudinal ribs. Stigma short-sagittate. —Canada to Alaska, extending into the mountains of Colorado, Nevada and Utah ; also found in Greenland and the mountains of Europe and northern Asia.

3. T. SPARSIFLORUM, Turczainow in litt. in Fischer & Meyer, Index Sem. Hort. Petropol. I, 40.—Stem firm, erect, leafy, 1–6 ft. high, with ascending branches. Leaves ample (contracted in the smaller specimens), 3-ternate, the lowest petioled. Leaflets approximated, short-petioled, thinnish, round or spatulate-oblong, $\frac{1}{4}$–1$\frac{1}{4}$ in. long, slightly cordate at base ; divided above into three obtuse or short-acuminate lobes that are again incised. Flowers perfect, not large, erect or soon nodding on slender pedicels in a short, branched, leafy panicle. Sepals obovate, whitish, soon reflexed. Stamens 10–20, the short exserted filaments widened

to the pointless elliptical anthers that are 1 mm. long. Achenia 8–15, short-stipitate, obliquely obovate, flattened, with 8–10 low, often forked nerves approximately parallel to the arched ventral margin; 4–5 mm. long and 2–3 wide, tipped by a beak $\frac{1}{3}-\frac{1}{2}$ as long, that is continuous with the nearly straight dorsal margin. Stigma elongated, unilateral.—Alaska and British Columbia, extending into the mountains of Colorado and California. From northern Asia.

Varies from glabrous throughout to glandular-pubescent on the achenia and the lower surface of the leaflets. This is T. clavatum of Hooker's Fl. Bor. Am. i. 2, and T. Richardsonii, Gray, Amer. Journ. Sc. xlii, 37.

4. T. MINUS, L. var. KEMENSE. T. flavum, 1, Kemense, Fr. Fl. Hall, i, 94. T. Kemense, Fr. Mantissa, iii, 48.—Erect, stout-stemmed, 1–2 ft. high, subsimple; glabrous or glaucous. Leaves 2–3-ternate, the lower short-petioled. Leaflets moderately firm, short-petioled, oval and narrowed to the base, once–twice 3-lobed at the summit, the pointed lobes divergent. Flowers perfect, erect on thickened pedicels in a strict panicle. Stamens 15–20 their filaments slender, elongated; anthers oblong, mucronate, 3 mm. long. Achenia 6–8 or fewer, sub-sessile, obliquely ovoid, subterete, about 6-grooved. Stigma broadly sagittate.—Alaska. From Europe and Asia.

The American plant is stricter and thicker-leaved than Asiatic specimens.

5. T. PURPURASCENS, L. Sp. Pl. 546.—Stem stout, tall, green or purple, leafy. Leaves ample, 3–4-ternate, the lowest petioled. Leaflets remote, short-stalked, firm; the upper surface dark-green; large (1–2 in.), mostly oblong or oblong-cuneate, with 3 commonly entire pointed lobes above. Flowers of medium size, in a pyramidal panicle, nearly diœcious. Stamens numerous, their long filaments widened to the linear-oblong cuspidate anthers that are 2–3 mm. long. Achenia numerous, densely clustered, short-stipitate; thin-walled, with 6–8 sharp longitudinal wings, those at the sutures most prominent; ovoid, 3–4 mm. long, tapering into the slender, persistent style. Stigma long and narrow.—From Canada to Florida and Texas; west to Arizona, Montana and Saskatchawan.

Varies from glabrous or granular to pubescent or glandular-pubescent. When prominently glandular and with a graveolent odor it is T. graveolens, Muhl. Fl. Lancast. Mss., which is var. ceriferum, Austin, of the Manual. With strongly revolute margins to the leaflets, it is T. revolutum, D C. Syst. I, 173; Lecoyer, Monogr. Thalict. 71. With pubescent achenia it becomes T. dasycarpum, Fisch. Mey. and Lall. Index Sem. Hort. Pet. 72, Lecoyer, Monogr. 70, which approaches the next species in its shorter anthers and wide, papillately roughened filaments. A thin-leaved form from Louisiana (Hall) and Indian Territory (Palmer), with very long, slender stigmas is T. macrostigma, Torrey in herb., which is approximated to the type by shorter-styled Arizona plants collected by Rusby. A questionable thick-leaved specimen from Fremont's Expedition of 1842 has also elongated stigmas.

6. T. POLYGAMUM, Muhl. Fl. Lancast. 176. T. cornuti of Gray's Manual, etc. T. corynellum, DC. of Lecoyer. (Cf. Gray, Am. Journ. Sc. Mar. 1886, 235–6.)—Of the general appearance of the last (rarely 6–8 ft. high) but with smaller leaves and leaflets. Flowers commonly andro-diœcious, more corymbosely clustered on the branches of the panicle, appearing smaller but more conspicuous in the male plants, from the crowded erect stamens, with white filaments broader than the oval, blunt or barely mucronate anthers that scarcely exceed 1 mm. in length. Achenia as in T. purpurascens but mostly narrower and longer-stalked, rarely pubescent. Stigma typically shorter and broader. — New Brunswick to Florida; west to Ohio.

Glabrous or pubescent, but not glandular. A conspicuously downy form is T. pubescens, Nutt.

I am indebted to Professor Goodale for the privilege of examining the large series of duplicate specimens of this and the preceding, collected in Connecticut by the late Charles Wright, who worked at them diligently for several years. So far as I have been able to observe, T. polygamum is never glandular, so that all specimens with glandular pubescence are apparently referrible to T. purpurascens; but I am unable to identify with certainty fertile plants that possess no stamens, when this character is wanting. Even when stamens are present they are not always satisfactory, for doubtful specimens occasionally occur with pointed anthers nearly 2 mm. long, and widened filaments. These are apparently forms of T. purpurascens, var. dasycarpum.

Certain specimens which resemble T. dioicum in having thin, glabrous (rarely sparingly pubescent), pale leaflets, rounded and round-lobed at the apex, but with the fruit stipitate, 2-edged and wing-nerved, as in T. purpurascens and T. polygamum, are regarded as hybrids.[1]

7. T. DEBILE, Buckley, Am. Journ. Sci. XLV, 175.— Glabrous. Stem from a cluster of fusiform tuberous roots, weak and decumbent, 4–14 in. high, sparingly branched or simple; few-leaved, with remote sheathing scales below ground. Leaves 2-3-ternate, on long, slender petioles. Leaflets $\frac{1}{3}-\frac{1}{2}$ in. long, long-stalked and remote, thin and pale, rotund, 3-lobed at the apex, the rounded lobes entire or again similarly lobed. Flowers small, diœcious, long-pedicelled and remote in an elongated, sub-simple, strict panicle. Stamens about ten, their filaments short but slender; anthers oblong-linear, mucronate, 2 mm. long. Achenia 2–5, subsessile, spreading, oblong, terete, with 8–10 ribs, nearly beakless. —Georgia, Alabama and Texas.

Var. TEXANUM, Gray, Cat. Coll. Hall, Pl. Tex. 3, is a form from Texas, with more rigid stem and smaller, thicker, nearly sessile leaflets.

8. T. DIOICUM, L. Sp. 768. Glabrous. Stem erect, 1–2 ft. high, not very stout, sparingly branched, leafy. Leaves 2–4-ternate, the lowermost petioled. Leaflets thin and pale, orbicular, or the terminal cuneate-obovate, 7–9-lobed at the summit, the principal sinuses widening at maturity; lobes rounded or short pointed. Flowers appearing with the leaves; diœcious, of medium size, drooping in lateral umbels that form a loose corymbose panicle in luxuriant specimens. Stamens many, their very slender filaments twice the length of the sepals; anthers linear, 2–5 mm. long, with a broad, thin point. Achenia 6–10, subsessile, ovoid; 3 mm. long, blunt or acutish, terete with 10–12 deep and equal, longitudinal grooves, separating as many stout, rounded ridges; thick-walled, filled by the seed. Stigma elongated, commonly breaking away, near the base.—Canada to Alabama, west to Kentucky, Nebraska and Minnesota. Specimens from the Atlantic States, both north and south, with nearly the foliage of this species but stipitate 2 edged achenia, are regarded as hybrids with T. purpurascens or T. polygamum.

9. T. VENULOSUM, n. sp.—Glabrous and glaucous, the stem, petioles and sepals purple-tinted, the foliage typically pale or whitened. Stem simple, erect, 7–20 inches high. Stem leaves 2–3, long petioled, 3–4-ternate. Leaflets approximated, short stalked,

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[1] For additional remarks on these two species see Bot. Gazette, Apr. 1886, pp. 92–3.

moderately firm, rounded and lobed at the apex as in T. dioicum, the lower surface rugose-veiny. Panicle simple, narrow, its short erect branches few-flowered. Flowers diœcious, small. Sepals ovate. Stamens 10–20, on slender filaments; anthers oblong, slender-pointed. Achenia about eight, nearly sessile, 4 mm. long, ovoid tapering into a straight beak; thick-walled and otherwise similar to those of T. dioicum except that they are 2-edged and commonly with one less groove on each side. Stigma sagittate. Seed ovoid, pointed at one end, 1×2 mm., filling the ovary.—British America (Franklin Expedition), Washington Territory (Vasey) Wyoming (C. Richardson) and Colorado (Parry and Vasey) Young plants were distributed with T. Fendleri in Parry's Rocky Mountain Plants of 1862.

A staminate specimen from Saskatchawan (Bourgeau) under the name of T. dioicum, appears to be this species with a more compound panicle than usual.

10. T. OCCIDENTALE, Gray, Proc. Amer. Acad. VIII, 372. T. dioicum var. oxycarpum, Torr., Bot. Wilkes' Exp. 212.—Habit and thin foliage of T. dioicum but the leaflets sparingly glandular-puberulent below. Flowers diœcious. Filaments purplish, slender, anthers linear, cuspidate. Achenia about ten, more or less reflexed, lanceolate or somewhat falcate, scarcely oblique, 8–10mm. long, tapering below into a short stipe, and above into a long one-sided curved beak; thin-walled, slightly 2-edged, with about eight parallel ribs occasionally forked or with shorter intermediate ones. Stigma narrow, elongated.—Vancouver's Island to California; east to Montana.

Referred to T. dioicum by Lecoyer, but distinct in the glandular-puberulent foliage and the long and slender thin-walled 2-edged achenia that are ribbed instead of furrowed. Flowers that may be of this species, from Hooker, in the Berlin herbarium, have in some cases blunt and pointless, in others long mucronate, anthers.

A simpler form from Washington Territory and Montana, with shorter and more flattened often glandular achenia (Fig. 10) appears to be T. megacarpum, Torrey,[1] the type of which, collected by Fremont on the Platte, has wider fruit than any of the later specimens. With more material it may be necessary to recognize this as a valid species.

11. T. FENDLERI, Engelm., Mem. Am. Acad. n. s. IV, 5.—1–3 ft.

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[1] Published by name only in Fremont's Rept. Expl. Exped. 1845, 87.

high, in foliage and habit intermediate between T. occidentale and T. sparsiflorum. Granular or glandular-pubescent. Lower leaves petioled, the stalked remote leaflets often deeply cordate, with three divergent lobes, the central or all of them again lobed, their divisions mostly pointed. Flowers diœcious. Stamens numerous, their slightly dilated filaments often papillose-roughened above; anthers linear, 2–3 mm. long, mucronate. Achenia ten or less (only a portion of the carpels reaching maturity), substipitate, 4–6mm. long, scarcely reflexed, obliquely oval or with the dorsal suture straightish, thin-walled, flattened, with 8–10 prominent nearly parallel ribs, the median heaviest; not filled by the oblong or linear seed.—Mountains, Texas to California, New Mexico and Colorado.

Var. WRIGHTII, T. Wrightii, Gray, Plant. Wright. part 2, 7, has usually smaller 3–4-angled plump achenia, more or less reticulately nerved and nearly filled by the oblong thick seed; and, commonly, smaller leaflets, very puberulent below.—Arizona and New Mexico.

Var. PLATYCARPUM has stricter panicles and dilated, sparsely glandular, erect achenia, 4–6 mm. long and as much as 4 mm. broad, often long-acuminate and somewhat free-veined; otherwise as in the type.—California.

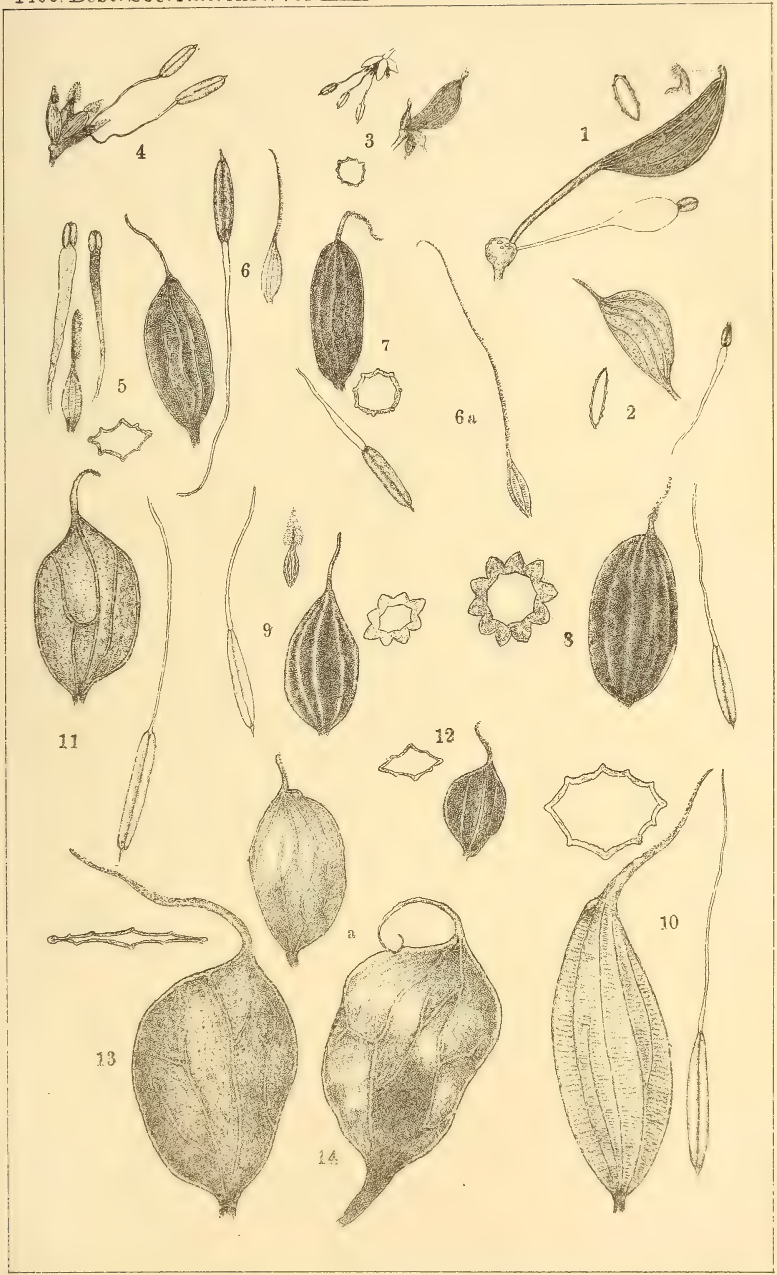
12. T. POLYCARPUM, Watson, Proc. Am. Acad. XIV, 288.—Foliage and habit of T. Fendleri, but glabrous throughout, with the leaflets longer-pointed and the flowers in stricter panicles. Achenia usually large, numerous in a dense globose head, obovoid, turgid (flat and undulate when dry), tapering into reflexed stipes; their thin walls with free or anastomosing low veins. Seed slender. —California.

The following Mexican species are recognized by Lecoyer, in his monograph above referred to:—T. Hernandezii Tausch. (p. 46), T. lanatum, Lec. (47), T. peltatum, DC. (49), T. pubigerum, Benth. (50), T. Galeottii, Lec. (56) and T. gibbosum, Lec. (57); but there is no indication that any of them occur on this side of the boundary.

EXPLANATION OF PLATE I.

DETAILS OF THALICTRUM.

1, *T. clavatum.* 2, *T. sparsiflorum.* 3, *T. alpinum.* 4, *T. minus.* 5, *T. polygamum.* 6, *T. purpurascens; a*, pistil of var. *macrostigma.* 7, *T. debile.* 8, *T. dioicum.* 9, *T. venulosum.* 10, *T. occidentale* (?), shorter form of fruit. 11, *T. Fendleri.* 12, *T. Fendleri*, var. *Wrightii.* 13, *T. Fendleri*, var. *platycarpum.* 14, *T. polycarpum; a*, smaller-fruited form.—Figures 2-4 are enlarged 3 diameters; the others, 5.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The Lewis Co. Boston.

TRELEASE, SPECIES OF THALICTRUM

Dr. C. C. Abbott of Trenton, N. J., read a paper on the habits of the white-footed mouse, Hesperomys leucopus. He had found the mice in October and November occupying, after reconstruction, the abandoned nests of robins, woodthrushes, grosbeaks and catbirds.

Prof. William T. Sedgwick showed several simple pieces of apparatus and devices in use in the Biological Laboratory of the Institute of Technology, including a convenient, adjustable, alcohol drip for the sledge microtome; some new methods of preparing and hanging diagrams; a pamphlet-case and an improved slide-case.

A fine bust of Agassiz by Henry Dexter, presented by Mrs. Nathaniel Thayer, was shown, and the thanks of the Society voted for the gift.

General Meeting, April 7, 1886.

The President, Mr. S. H. Scudder, in the chair.

Dr. R. R. Andrews read a paper on the development of the teeth, showing a fine series of sections of embryonic teeth in illustration.

Dr. S. Kneeland spoke of some metallic tubes, which formed part of a girdle found around the skeleton in a Fall River grave known as the "skeleton in armor." All the metallic contents of this grave were sent by Dr. J. V. C. Smith, of Boston, to the Ethnographic Museum of Copenhagen in 1841 and there they still remain. He exhibited three of the more than forty tubes which constituted this girdle, reading the original description from the "Memoirs of the Antiquarian Society of the North," 1840–44. From the burial in a sitting posture, the wrappings, the cedar bark covering, and the absence of any articles of undoubted European manufacture, it seems undeniable that this was the grave of an American Indian, pure or half breed, and after contact with the whites. The tubes were a little over four inches long, and one-fourth of an inch in diameter, formed around hollow reeds through which were passed strips of raw hide; the metallic, vegetable, and animal portions were well preserved. As shown by the analyses of Berzelius, and of Prof. R. H. Richards of Boston, these tubes are of brass, not of bronze nor copper; and were probably made from parts of a brass kettle obtained from the whites. The grave most likely dates from about 1650, when the locality had been occupied by the whites about thirty years. The girdle was doubtless an ornament, and in no sense armor. It is placed in Copenhagen among the American antiquities of the Stone Age. Though copper tubes of similar structure have been found in various parts of the United States, especially in the west, and these tubes were undoubtedly of Indian manufacture, he thought that the idea of this kind of ornamentation was of European origin, and most likely from Scandinavia, using this term in a geographical and not in an ethnological sense, antedating the visits of the Northmen in 1000–1007. He gave many instances of similar ornaments from the Bronze Age in Northern Europe, to be seen in the Antiquarian and Ethnographic Museums of Copenhagen, quoting works, recently published, in which they are figured. He thought that the Norsk colonies in Greenland, for three centuries, had imparted many European ideas of art and ornamentation to the Eskimo tribes and to the Algonquin races of the American Indians.

Mr. F. W. Putnam showed some brass arrowpoints from an Indian grave at Revere like those found with the Fall River skeleton, and also some similar tubes, but of copper, from a western grave. The tube style of ornament seems a common one among the American Indians.

General Meeting, April 21, 1886.

Vice President, Mr. F. W. Putnam, in the chair.

Mr. Percival Lowell read a paper on the Korean language, discussing its affinities, and peculiarities of construction.

Professor Hyatt showed and explained a series of models illustrating the development of Amphioxus. The models are a gift to the Laboratory from Mr. R. C. Greenleaf, and afford most valuable aid to students in acquiring an intelligent idea of vertebrate embryology.

A note on the supposed Myriapodan genus Trichiulus Scudder, by S. H. Scudder, was read by title. (See Memoirs, B.S.N.H., III.)

ANNUAL MEETING, MAY 5, 1886.

The President, Mr. S. H. Scudder, in the chair.

The following reports were presented:

REPORT ON THE MUSEUM. BY A. HYATT, CURATOR.

The slow progress of the Museum needs no explanation to one acquainted with the condition of the Society's funds. The work, begun some fifteen years ago, has been constantly and effectually retarded for want of means either to obtain the few specimens and preparations needed, or to retain the services of assistants who have been educated to the work. We have gained ground in spite of all drawbacks, but we cannot congratulate ourselves upon the rapidity of this process, or the prospects of the future.

The introductory collections which were reported upon last year, as having become necessary in order to complete the Museum, have been begun and considerable progress made. Two cases, out of the six needed for their accommodation, have been constructed and set up in the main entrance hall. They do not, in any way, interfere with the architectural effect of the hall as was feared. Professor Crosby has been at work upon the dynamical geology and hopes to complete this portion and place it on exhibition in the two cases just mentioned early in the next official year.

The curator has also been occupied with the corresponding biological collections, which will require several years on account of the necessity of procuring a number of preparations, some of which will have to be purchased while some can be made by assistants in the Museum. Considerable can be accomplished with the materials now on hand, or easily procurable, and possibly, enough progress may be made to permit the issue of a provisional guide for the whole Museum before the introductory collections are entirely completed.

Even a provisional general guide would not be satisfactory, unless it included some review of the first collections with which the visitor came in contact, and it is evident that these must be in large part prepared and placed on exhibition before such a step is taken.

Mineralogy.

Professor Crosby has been engaged in rewriting and condensing the Guide to the collection of Comparative Mineralogy, and with Miss Carter's assistance, has entirely revised and renumbered the specimens of this division. Professor Crosby and Miss Carter have also carefully, as a final step, rearranged and numbered the systematic collections, which now comprise over three thousand specimens. A large portion of Professor Crosby's time has been expended in writing the Guide to the Systematic Collection and in revising proofs of both sections of the guide, which has been alluded to in previous reports. This is now wholly in print and will soon be issued for public use.

One hundred specimens have been added to the collection during the year and these have been catalogued and mounted by Miss Carter.

Geology.

Professor Crosby has selected and prepared nearly all the specimens in the collections of this department, which are suitable for the illustration of the important and difficult division of dynamical geology which is to be shown in the introductory collection. He is now engaged in completing this collection, which will necessarily contain quite a number of preparations and illustrations requiring more or less time and study, and also in writing the guide relating to this section of the introductory collections.

Miss Carter has catalogued and mounted the accessions, which number one hundred and twenty-five specimens.

Botany.

The unsolicited generosity of Mr. John Cummings still continues to relieve the society from any anxiety with regard to this collection, and has considerably assisted us in other departments of the Museum, in which the services of his assistants have enabled us to make progress not otherwise practicable.

Miss Carter under Mr. Cummings' direction has continued the review of the herbarium with relation to the synonymy, and has nearly completed the phenogamous plants.

The supplying of deficiencies among the endogens is not quite finished and the full report is, therefore, postponed until next year. The ferns have been revised, and the work of perfecting the New England Herbarium by supplying it with the best specimens from all genuine New England localities has been begun. Miss Carter has also spent considerable time in the necessary work of poisoning plants.

The principal accession of the year has been the very fine collection of North American lichens given by one of our oldest and most highly honored members, Mr. Charles J. Sprague. This collection has been properly catalogued by Miss Carter and a special report by Dr. Farlow was prepared and read at a recent meeting of the society. The collection contains 2635 specimens, representing 78 genera and 849 species and varieties. Many of these are very rare and valuable additions to the Herbarium.

Comparative Anatomy.

Mr. Henshaw has made, with materials given by several persons, a few alcoholic and forty osteological preparations of reptiles, birds, carnivora and monkeys.

Dr. Dwight has presented a few sections of the long bones of various mammals prepared from materials lent him by the society. Mr. Henshaw has begun the mounting of the sea lion given some years since by Capt. Charles Bryant.

Sponges.

Miss Martin has worked over and labelled all the materials not on exhibition. Preliminary work upon the Keratosa of the Bermuda collection has been completed, and it is expected that the whole Bermuda collection can be finished and got out of the way next year.

Mollusca.

Mr. Henshaw and Miss Martin have made considerable progress in the identification of the genera, and labelling of the miscellaneous materials in this department.

During the progress of this work the exhibition collection has been modified in order to admit a more extended series of forms.

This work will be completed, and a final report made next year.

Insects.

Dr. S. W. Williston has named and returned our collection of Asilidae and Tabanidae. While engaged in the work of collecting materials for the Teachers' School of Science, Mr. Henshaw was able to obtain between five and six hundred specimens of value to our Museum from New England, Florida and Texas. These have been labelled, and about two-thirds have been identified.

Mr. Edward Burgess has presented his general collection of insects, which will be reported upon next year, and also some alcoholic materials of insects and other invertebrates. Donations have also been received from Dr. H. Hagen and Messrs. S. H. Scudder and F. H. Sprague.

Birds.

Mr. Henshaw has completed the rearrangement of the Passeres and Picariae, which occupy one-half of the upper gallery and two side rooms. He has arranged the genera in the sequence followed by Wallace, and has grouped the species of the same geographical regions together.

Large labels indicating the characters, and giving the distribution of all the different families, have been prepared for printing.

The late Dr. Samuel Cabot had desired that his cabinet of birds might be given to the society, and his wishes were carried out by his heirs during the past official year. This collection is of great value since it contains the types described by Dr. Cabot in the Proceedings of this society, and a number of birds very valuable for our New England collections. About three-fourths of the mounted specimens have been identified by Mr. Brewster and these have been catalogued and distributed by Mr. Henshaw in the general collections. The collection consisted of 400 mounted birds and a little more than 900 skins. The skins have been safely stored in cans.

Mammalia.

A few species have been added to the New England and General collections by exchange and donation.

The departments not mentioned remain substantially the same as when last reported upon.

Teachers' School of Science.

The liberal action of the trustee of the Lowell fund in defraying the expenses of the lessons, and also in continuing to grant the use of Huntington Hall, has enabled the Society to persevere in its effort to extend the benefit of the instruction in this school to teachers of all the neighboring towns as well as to those living in Boston. The agents who acted in the adjoining towns and villages last year continued their kind offices, distributing and receiving applications and also tickets according to the plan of which details were given in a former report. The Superintendent of Public Schools in this city has also kindly assisted us by attending to similar technical details in Boston.

During the past winter the Curator gave fourteen lessons upon the structure and habits of Worms, Insects and Vertebrates, beginning Nov. 7, 1885, and ending March 13, 1886.

The work was in part directed to the subjects prescribed in the "Observation Lessons" of the Primary, and the "Elementary Science Lessons" of the Grammar Schools of Boston.

The manner in which the types of Worms and Vertebrates had been prepared made it possible to explain their general anatomy from the objects, in place of the diagrams commonly used. The soft bodies of the types mentioned were tanned in many cases so that the exterior resembled in aspect, color and odor, a kid glove recently cleaned with naphtha. Notwithstanding these changes, which rendered the specimens agreeable for use, all the organs, and even most of their minute structural characteristics, are well preserved, and some of their most important peculiarities could be more readily seen than in fresh dissections. The discovery of this mode of making anatomical preparations has rendered the instruction of large classes possible even in the anatomy of the vertebrata, and they will, it is hoped, be eventually used by teachers in dealing with such subjects whenever fresh specimens are impracticable or unobtainable.

The lessons on insects were enlarged in scope and doubled in number in order to meet the demands of the teachers, who, as a general thing, find this type of animals more available for use in the class room than any other. Thus in place of ten lessons, as first advertised, fourteen were eventually given, each one being considerably over one hour in length.

The interest of the audience was such that at the end of the hour, though a pause was purposely made, only one or two would leave, and often not one would go until the end of the lesson which frequently occupied an hour and a half.

Without the energetic assistance of Mr. Henshaw the course would not have been practicable and it is very doubtful whether another of a similar kind, at least on so large a scale, will ever again be considered justifiable.

The lessons were highly appreciated by the best class of teachers and we were repeatedly informed by those well capable of judging, that they were very satisfactory. Nevertheless the difficulties overcome and the anxiety and labor of collecting and tanning by the hundred such animals as kittens, pigeons, etc., tasks the strength of an assistant beyond what should be considered right or healthful.

The number of specimens distributed last year in the first ten lessons of this course was 10,500 ; during the present winter 18,035 were given away, making for this course in Zoology a grand total of 28,535 specimens. These were preparations requiring time and care and two thousand and six hundred were tanned specimens.

The weather was the worst in our experience, clear afternoons being very rare. The average attendance was much reduced by this fact, and amounted to one hundred and thirty-one at each lesson. While there has been a steady falling off in numbers for the past five years, there has been a constant gain on the part of those persevering in attendance, because of the more advanced instruction which could be given.

Besides the lessons by the Curator, twenty practical laboratory lessons of two hours each in Mineralogy were given by Prof. W. O. Crosby. These were directly continuous with those delivered by him last winter, and were also intended to prepare teachers for giving instruction in "Common Metals, Minerals and Rocks," according to the plan indicated in the schedule of the "Course of Study for the Boston Grammar Schools." They consisted exclusively of practical lessons given in the Mineralogical Laboratory of the Massachusetts Institute of Technology, and the class was necessarily limited to sixty teachers.

The thanks of the Society are due to the Massachusetts Institute of Technology for the use of their Laboratory during the two winters occupied by this course.

The advantages of the instruction could be offered to *all* the Grammar Schools only by asking each master to assist in organizing the class ; and he was accordingly invited to send to Mr. Seaver, Superintendent of Public Schools, the name of one teacher who would be interested, and to whom it would be practicable to assign the instruction in minerals, etc., in his school.

By permission of the Trustee of the Lowell Fund, a fee of one dollar and a half was charged to cover the cost of specimens and apparatus ; and these the teachers were allowed to retain.

The course began on Jan. 3, 1885, and is not yet entirely finished. The last lesson will be given on May 28th.

The teachers being selected for this class were much more regular in their attendance than in the larger classes, and seemed to realize the value of their opportunity.

The average number at each lesson so far has been forty.

Number of applications received 520.

Number of tickets distributed.		To teachers.		To others.	
Zoology	634	Zoology	429	Zoology	205
Mineralogy	62	Mineralogy	61	Mineralogy	1
	696		490		206

GRADE OF TEACHERS.

Boston Public Schools. Tickets distributed to	Zoology.	Out-of-town Schools. Tickets distributed to	Zoology.
Superintendent	1	Superintendents	0
Masters	15	Masters and Principals	32
Sub-Masters	11	Sub-Masters	11
Assistants	241	Assistants	128

LIST BY TOWNS.

Andover	1	Framingham	2	Quincy	16
Belmont	2	Hyde Park	9	Salem	2
Boston	268	Linden	1	Somerville	19
Bridgewater	3	Malden	5	Stoneham	1
Brockton	1	Medford	16	Wakefield	4
Cambridge	41	Melrose	6	Wellesley	1
Canton	1	Needham	1	Weymouth	5
Chelsea	20	Newton	15	Wollaston	1
				Total	429
				Complimentary	166
				Miscellaneous	39
					634

Winter Laboratory.

The laboratory has been used by the following classes: one in Zoology and Paleontology and one in Heredity, from the Mass.

Inst. Technology, one in Zoology from the Boston University, these three being under the charge of the Curator; also, one in Botany and one in Physiology, from the Boston University, both of these last being under the charge of Mr. B. H. Van Vleck. There has been unusual activity in this department, and its teaching power has been augmented by the addition of selected specimens and diagrams. The principal among these is a series of twenty-five models, given by Mr. R. C. Greenleaf. They are accurate copies of Hatscheck's illustrations of the embryonic stages of Amphioxus, showing the development of the endoderm, nervous chord, notochord, mesodermal somites and endoderm. This is done with such clearness that even a beginner in zoology can with their aid be made to comprehend the evolution of the principal layers in the body of a vertebrate from the single cell of the ovum and the two primitive layers of the gastrula. Models are evidently great aids in the teaching of general principles and our Laboratory needs more of them.

The lecture room in the basement has become too small for the accommodation of students, and the Society has begun the refitting of the quarters formerly occupied by the janitor with the intention of making a more spacious and better ventilated class room.

Summer Laboratory.

This department, as in former years, has been carried on by means of a donation from the Woman's Education Association, whose members continue to show a very gratifying interest in our work.

The Curator being absent, the entire charge of the laboratory devolved upon the voluntary labors of Mr. Van Vleck who conducted it with his usual ability and success.

The number of students were thirteen in all, four women and nine men. The average time of each student in attendance was four weeks and one day. The average of time for each student was larger than in previous years, showing a gratifying improvement in this respect, though the whole number of students was two less than last year. As we have repeatedly said, the influence of this laboratory is not to be measured by the number of students. For example, we have good reason for thinking that Mr. Van Vleck's work during this last summer has materially influenced the future of science-teaching in two colleges, and in the public schools of one southern state, through three of the students. If we had had only these three students without reckoning the ten others, some of whom were teachers also and influential persons, the laboratory would have made ample returns for the amount expended in keeping it open. A few summers since the same remark might have been made with regard to a single student who now influences over nine thousand pupils by his personal efforts in superintending the teaching of natural history, and who has given testimony of his high appreciation of the value of our instruction as an aid in his work.

Expedition.

During the summer of 1885 an expedition was made to the West Coast of Newfoundland and the nearly approximate fossiliferous part of the coast of Labrador in the yacht Arethusa. The Curator started ahead of the schooner on the 8th of May, going to St. Johns in order to inspect the Geological Museum, and make other preparations. From that place he went by steamer to Port au Port on the West Coast of Newfoundland arriving there on the third of June. The yacht started from Annisquam under the charge of Dr. E. G. Gardiner and after a stormy and uncomfortable passage anchored at Port au Port, June 17.

A large collection of fossils had already been made at this place by the Curator, and after these were taken on board, and some days had been expended in completing the exploration of this locality, which is the key to the geology of a considerable part of the coast, the expedition departed on its way northwards.

Dr. E. G. Gardiner had charge of the navigation and the success of the expedition is largely due to his interest and good management. Mr. George Barton, Instructor at the Institute of Technology, was my immediate and very efficient assistant in the geological work, Dr. Howard M. Buck of Boston took charge of the health of the crew, and of the sick who came aboard appealing for help which could not easily be refused, there being only one physician resident on the entire west coast. Mr. Sidney R. Bartlett, student of the Institute, acted as photographer, and succeeded in obtaining about 180 pictures, most of them excellent. Mr. C. L. Burlingham, also a student of the Institute, helped Mr. Bartlett and also assisted in collecting fossils. All of these gentlemen contributed to our success and the Curator has to thank them personally for the advantage never before enjoyed of giving his time solely to the scientific interests of the expedition.

The following is republished from a report of the results which appeared in Science, Vol. vi, No. 143, Oct., 1885.

The weather while going and returning was not favorable, but on the coast of Newfoundland and Labrador, from June 17 to about August 10, it was very fine, and greatly facilitated the work of the shore parties. The prevalence of high winds made opportunities for dredging exceptionally rare, and very little was accomplished in this direction. The shores proved, also, excessively barren ; the pools were infrequent and not rich in species. From Cape Ray to St. John's Island, for the distance of two hundred and fifty miles on the western coast of Newfoundland, the principal mountain ranges, whose general course is north-east southwest, approach the sea more or less closely. They are so arranged that they present their ends to the sea on the south coast, and are seen more from the side on the west coast. From St. George's Bay to St. John's Island, on the western coast, they form a series of steep cliffs, cones and domes, which also greatly enhance the beauty of the deep and branching fiords of Bay of Islands and Bonne Bay. The climate, vegetation and lovely harbors, made the trip along this part of the route a series of delightful surprises.

The only population on the west coast consists of small settlements of fishermen, with a very few persons of a higher grade. Besides these permanent inhabitants, there are several fishing settlements of French, who come only for the summer. They still have fishing privileges on and off this coast, but are not allowed to erect permanent habitations. These rights and the islands of the St. Pierre group on the south coast, where their flag flies, are the remnants of the once extensive territories of the French nation on this continent.

Fossils were collected at various localities along the west coast from near Cape St. George to Cape Norman, the northernmost point of Newfoundland, and at the Atlantic entrance of the straits of Belle Isle. These fossils fairly represent the faunas of the formations called Quebec and Point Levis groups by the Canadian survey, and the Trenton and Lower Carboniferous of the Newfoundland survey.

The facilities for acquiring fine specimens of fossil cephalopods far exceeded the most sanguine anticipations. Several well preserved specimens of the imperfectly-known and curious, primitive form, Piloceras; fragments of orthoceratoids allied to Endoceras, which are more than two feet long and four inches in diameter at the living chambers; a number of large cyrtoceran shells, and a considerable number of more or less perfect, close-coiled and lituites-like Nautiloidea are among the principal acquisitions. The latter include all the species originally described by Billings from Newfoundland, and probably some new species.

It may be provisionally stated that Piloceras is a curved or cyrtoceran form of Endoceras, and that Actinoceras also had a curved shell in some species, which was not less than thirty inches in length.[1] Two fine specimens of the latter with very long, living chambers, were dug out near Point Rich.

The limestones of the Quebec group form a continuous and unbroken series of conformable strata, which are particularly well shown at Port au Port. The large numbers and prevalence of gasteropod shells of the genera Maclurea, Pleurotomaria and Murchisonia, fragments of Isotelus and Asaphus, and the abundance of Endoceras-like Orthoceratoids and Actinoceras, together with transversely-ridged species like Orthoceras vertebrale, give the fauna of the uppermost of these limestones at Port au Port a Lower Silurian aspect. These resemblances, however, are counterbalanced by marked differences. Thus there is a comparative scarcity of Brachiopoda, and there are no massive corals which can be considered as having materially aided in the accumulation of the rocks. The presence of ancient forms like Archeocyathus and Calathium, which are probably sponges, and of Piloceras, and the comparative abundance of the coiled forms and partly-coiled Nautiloidea with open umbilici and cylindrical whorls, indicates a primitive assemblage of organisms more ancient than the Lower Silurian, and evidently introductory to that fauna.

At Port au Port, also, the actual contact of the Levis slates with limestones of Quebec was studied. These rocks contain Lingulae in abundance, and also Trilobites, already described by Billings. It cannot be questioned that they lie above the limestones and are conformable, though having an entirely distinct fauna.

Above this lies the so-called Sillery conglomerates and sandstones, a series of unfossiliferous strata. As described by Richardson of the Canadian survey, and Murray and Howley of the Newfoundland survey, they are also comformable, but overlie the Levis slates.

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[1] This is a strong confirmation of the author's views that the same group of Nautiloidea and Ammonoidea may have straight, bent or cyrtoceran, and even close-coiled shells.—*Science*, Nos. 52-53, 1884, and Proc. Am. Assoc. Adv. Science, vol. 32.

A fault, already traced by Murray and Howley, separates the northern horizontal outcrop of the Sillery at Long Point, Port au Port, from Murray and Howley's Trenton limestones.

The fauna of these last is certainly like that of the Trenton of New York, but it has a decidedly Newfoundland facies, and its only visible contact is along the perpendicular fault above mentioned. It contains a great abundance of Bryozoa, Brachiopoda, and reef-building corals, which remind one constantly of the aspect of the Trenton fauna, and has altogether a more modern aspect than the Quebec faunas. It is not yet ascertained whether the Endoceratites found are true Endoceras, but fragments of an undoubted Gonioceras were collected in considerable numbers in the lower series of these rocks. It seems, therefore, very probable that Murray and Howley are correct in considering the strata at the end of Long Point as the equivalents not only of the Trenton proper, but also of the Black River and Bird's Eye faunas.

All of the rocks in this part of the island dip away from the mountains in a southwesterly direction, passing out of sight under the waters of the Gulf of St. Lawrence. Thus the outermost strata are, in a general way, more recent than those lying inland or nearer the mountains. The geological position of the Trenton at the end of Long Point, Port au Port, is not far out to sea, but the well-marked fault which occurs between it and the Sillery to the south, or the same narrow point, shows that it is a fragment of an overlying formation, which, having fallen to its present level, has been preserved, together with the older rocks immediately adjoining.

The immediate contact of the Quebec limestones and underlying sandstones and quartzites was seen but not closely examined.

There can, however, be but little doubt that the quartzites of Bonne Bay, on the east shore of the east arm, lie as described by Richardson and mapped by Murray, directly underneath the Quebec limestones, and are comformable. Whether they are the equivalents of the Potsdam or not can only be determined from Richardson's observations and collections.

Collections were made at Anse au Loup and Amour Cove in the so-called Potsdam sandstones and limestones of the Canadian survey. The observations made at these points indicate a fauna quite distinct from those of any of the limestones or slates of the west coast of Newfoundland. The absence of Cephalopoda and the prevalence of primitive forms of Archeocyathus show the rocks to be probably older than those of the Quebec group at Port au Choix and other localities. The primitive sponges, or Archeocyathi, have here replaced corals completely, and may be described as reef-builders, since numerous hummocks and masses and parts of the strata are formed entirely of their remains. Immediately below these limestones, and conformable with them, lie the red sandstones, several layers of which are perforated with Scolithus burrows.

The geological evidence brought forward by Sir William Logan in the report of Canadian geological survey, 1863, to prove that the straits of Belle Isle have been partly formed by a synclical valley, appears to us to be very defective. It is more in accord with the evidence to consider that the whole of northern Newfoundland was once much more elevated, and has been sunk by faulting until at the straits the Quebec has been brought down to the same level as the red sandstones of the opposite Labrador shore. The origin of the straits would in that case be considered as due to the changes of level produced by one or more of the same great series of parallel faults already traced by Richardson, Murray and Howley along the west coast. These run parallel with the axis of the straits, and seem to account fully for all the phenomena.

Observations were made upon the raised beaches and terraces which occur along the shores of Newfoundland and Labrador; and here, as well as at Anticosti and the Mingan islands, the marks of the recent elevation of the land are abundant.

REPORT OF EDWARD BURGESS, SECRETARY.

The following report is respectfully submitted.

Membership.

The Society has lost during the past year three Associate Members by death, and four by resignation, while four have been dropped for non-payment of dues, and two have removed from New England. One Corporate Member has forfeited membership, and one Patron, Mr. Henry P. Kidder, has died. Ten Associate, four Corporate, and four Corresponding Members have been elected.

Meetings.

Sixteen General Meetings have been held as usual, and it is pleasant to note an increased attendance, the average being thirty-one; eighty-two persons were present at the largest meeting, and eleven at the smallest. Thirty-three communications were made at these meetings.

Library.

The additions to the Library exceed the number reported last year, then far the largest recorded, by 218, the total of 2,883 being made up as follows:

	8vo.	4to.	Fol.	Total.
Volumes,	280	71	5	356
Parts,	1,655	326	167	2,148
Pamphlets,	306	24	2	332
Maps,				47
			Total:	2,883

The largest gift has been received from the Editor of "Science" and it includes several useful journals and other works.

Dr. C. S. Minot and Professor Hyatt have also presented a number of books. One hundred and sixty-nine volumes have been bound.

The rapid increase of the library will make necessary the addition of more shelf room at once, and the present seems to be the proper time for making any change in the system of shelf classification. That a better classification is desirable cannot be doubted, but whether a change is practicable, on account of the great labor involved in a library numbering nearly thirty-thousand works, is a question which the Library Committee now have under consideration.

Eight hundred and seventy-nine works have been borrowed by one hundred and five persons.

A sad duty to perform in connection with the Library is to record the death of our faithful assistant Librarian, Miss Lucinda Foster. Miss Foster served the Society for fifteen years, and after several years of great suffering died last June. Her cheerfulness, kindness of heart, and zeal in performance of her duties will long be remembered by all of us.

Publications.

At the beginning of the Society's year the Publishing Committee decided to abandon the plan of having the publications printed on the Society's premises, where the work has been done for twenty years, and arrangements were made with the Salem Press to undertake this work. It was hoped that the facilities of a large office would enable the publications to be more promptly issued, but for various reasons this has not yet been accomplished. Next winter will doubtless show proper improvement.

Part I of vol. XXIII of the Proceedings has been issued and part II is nearly ready, bringing the date down to last March.

A memoir by Dr. W. K. Brooks on the life-history of the Hydromedusae is in press and will be issued next month. Two memoirs by Mr. S. H. Scudder on fossil insects are also in type.

Walker Prize Essays.

The Committee on Walker Prizes reported that only one essay had been offered for the Walker Prize of 1886—Subject: "Original unpublished investigations of the life history of any plant," and the Committee recommended that the first prize should be awarded to its author.

The report was accepted, and the envelope containing the author's name being opened, Mr. Douglas Houghton Campbell of —— was declared the winner of the Walker Prize for 1886.

The Auditing Committee, Messrs. Cummings and Greenleaf, reported that they had examined the Treasurer's accounts and found them correctly cast and properly vouched.

ANNUAL STATEMENT OF RECEIPTS AND EXPENDITURES, MAY 5, 1886.

May 1, 1885, to May 1, 1886.

Admission Fees	$ 50.00	
Annual Assessments	1,235.00	
Dividends and Income from General Fund	3,644.05	
Income from Walker Fund	2,143.24	
" " " Prize Fund	300.00	
" " " Grand Prize Fund	7.00	
" " Courtis Fund	407.00	
" " Bulfinch St. Estate Fund	1,846.30	
" " S. P. Pratt Fund	531.82	
" " Huntington F. Wolcott Fund	414.00	
" " Entomological Fund	17.50	
Laboratory, Boston University and Students' Fees	3,026.75	
		$13,622.66

May 1, 1885 to May 1, 1886.

Museum	$825.28	
Library	442.07	
Salaries and Wages	6,989.00	
Fuel	255.25	
Gas	39.00	
Repairs of Building	211.89	
General Expenses	951.22	
Insurance	45.00	
Laboratory	3,193.24	
Unexpended Balance	670.71	
		$13,622.66

Teachers' School of Science, balance on hand from last year	$662.32	
Donation from Augustus Lowell, Trustee	1,000.00	
To Balance	215.49	
		$ 1,877.81

Teachers' School of Science, expended for Lectures, etc	$1,877.81	
		$1,877.81

BOSTON, MAY 5, 1886.

CHARLES W. SCUDDER,
Treasurer.

The Society then proceeded to ballot for officers for the year, and the following list was unanimously elected:

OFFICERS FOR 1886–87.

PRESIDENT,

SAMUEL H. SCUDDER.

VICE-PRESIDENTS,

JOHN CUMMINGS, F. W. PUTNAM.

CURATOR,

ALPHEUS HYATT.

HONORARY SECRETARY,

S. L. ABBOT.

SECRETARY,

EDWARD BURGESS.

TREASURER,

CHARLES W. SCUDDER.

LIBRARIAN,

EDWARD BURGESS.

COUNCILLORS,

Henry P. Bowditch,
William M. Davis,
George Dimmock,
Walter Faxon,
Charles L. Flint,
George L. Goodale,
Robert W. Greenleaf,
Henry W. Haynes,
B. Joy Jeffries,
Augustus Lowell,
Theodore Lyman,
Charles S. Minot,
Edward S. Morse,
William H. Niles,
William T. Sedgwick,
N. S. Shaler,
Charles J. Sprague,
Samuel Wells,
William F. Whitney,
Roger Wolcott.

MEMBERS OF THE COUNCIL, EX-OFFICIO,

Ex-President, Thomas T. Bouvé.
Ex-Vice-President, Richard C. Greenleaf.
Ex-Vice-President, D. Humphreys Storer.

The following members were elected :

Associate Members: Mr. Francis S. Child and Dr. Wm. D. Hodges.

Corporate Member: Mr. Roland Hayward.

Corresponding Members: Prof. Lorin W. Bailey, Fredericton, N. B., and Mr. Alfred W. Howett of Sale, Gippsland, Victoria.

Dr. G. L. Goodale occupied the rest of the evening with an interesting abstract of a paper on Plasmolysis.

GENERAL MEETING, MAY 19, 1886.

The President, Mr. S. H. Scudder, in the chair.

A letter from Mr. Douglas H. Campbell acknowledging the award to him of the Walker Prize, and thanking the Society for the honor, was read.

Mr. F. W. Putnam described the methods of manufacture of stone implements by primitive man, and showed a collection of jade celts, chisels and other objects from New Zealand, the Swiss Lake Dwellings and Peru. He also showed various ornaments from Peru made out of old jade celts, indicating early migration from Asia to America, for these Peruvian specimens are of a jadite of Chinese character, while the mineral is not found in place in America.

Dr. C. S. Minot reviewed the question of the origin and morphology of the mesoderm, showing the relation between the anastomosing tissue of the mesoderm and the epithelium.

GENERAL MEETING, OCTOBER 6, 1886.

The President, Mr. S. H. Scudder, in the chair.

The President announced the death of Prof. William Ripley Nichols, at Hamburg, July 14, after an active membership of fifteen years.

The following paper was read :—

CORRECTION. *Substitute the following for the second paragraph under the meeting of May* 19, 1886, *page* 324.

Mr. F. W. Putnam described the methods of manufacture of stone implements by primitive man, and showed a collection of celts and other objects of jade and jadite from New Zealand, the Swiss Lake dwellings and Central America. He also showed various ornaments from Central America, which had been made by cutting up celts. As these Central American jadite objects are of the same varieties of the stone found in place in Asia, and as these varieties are not yet known from America, he thought these specimens might indicate that their original owners brought them in early times from Asia.

ON THE GREAT DIKES AT PARADISE, NEAR NEWPORT.

BY W. O. CROSBY AND G. H. BARTON.

The locality near Newport known as Paradise is about two miles east of the city, and one-fourth mile north of Sachuest Beach and the chasm called Purgatory.

Mr. Dale[1] well describes it as "covering about one square mile, and consisting of a series of more or less parallel, north-south, rocky, precipitous or rolling ridges and hillocks of varying altitude, the highest measuring from 80 to 173 feet above the sea. The sides of several of these ridges are covered with their débris, the intervening spaces are sprinkled with boulders, and the whole tract bears evidence of the destructive element in geological history. The name Hanging Rocks is applied to the easternmost elevated ridge."

Probably few localities in New England have proved more puzzling to geologists; but we are confident that misapprehension of the nature of some of the rocks has caused the structure to be regarded as much more complex than it really is. All observers have detected an intimate relation between the topography and geology of this district. President Hitchcock[2] and Prof. C. H. Hitchcock[3] have recognized three principal north-south ridges, the most easterly of which is the Hanging Rocks; but Mr. Dale describes the topography more accurately as "comprising four high and three low ridges, all trending N.N.E., but in places somewhat curved, in others coalescing to form a lesser number of ridges." For the details of the topography, with the accompanying map and contours, as well as for a full bibliography of the geology of Paradise, the reader is referred to Mr. Dale's paper,[4] which is entitled to rank among the most valuable contributions to the geology of Rhode Island.

The ridges of Paradise, with the intervening valleys, are composed of three kinds of rock: (1). The extremely coarse quartzite conglomerate, which is so well developed in the Hanging Rocks and in the cliffs at Purgatory, and the metamorphism of which was so ably investigated by the elder Hitchcock.[5] This wonderful rock occupies a well-established position in the carboniferous series of Narragansett Bay, and there is essentially no difference of opinion concerning either its nature or its stratigraphic relations. It forms the two westernmost ridges of Paradise (ridges I and II of Dale's map), and its structure here, as explained by Dale, is synclinal. Ridge I is a northern extension of the cliffs at Purgatory, and along this entire line the conglomerate dips eastward about 70°, being underlaid conformably on the west, as Dale has so clearly shown, by the gray slate of Easton's Point, which forms a well-marked anticlinal axis here. This slate outcrops again under the conglomerate along the western border of Paradise. In ridge II the dip of the conglomerate changes to westerly at a high angle. The conglomerate also forms the two easternmost ridges of Paradise (VI and VII), Hanging Rocks and the low, ill-defined ridge or line of ledges along its eastern base. The dip in these two ridges, at all points examined by us, is toward the west at high angles, 70° to 90°. Mr. Dale's determinations of the dip in the Paradise district appear to be generally correct, although the angles seem in many cases to be steeper than he has recorded; but we are entirely unable to agree with him that the conglomerate in ridge VII dips to the east; and we find that the gray slate exposed on the east of the conglomerate has the same steep westerly dip, appearing to underlie the conglomerate conformably, as on Easton's Point and along the west side of Paradise.

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[1] Proc. Bost. Soc. Nat. History, XXII, p. 184.

[2] Geol. of Mass., p. 535.

[3] Geol. of the Island of Aquidneck, p. 113.

[4] Proc. Bost. Soc. Nat. Hist., XXII, 179-201.

[5] Am. Jour. Sci., 2d Series, XXI.

(2). Passing toward the central ridges of Paradise, we find the conglomerate upon either side succeeded by slate. President Hitchcock described it as a hard graywacke slate; and we regard it simply as a gray or greenish-gray clay slate, indistinguishable from that underlying the conglomerate on Easton's Point and on the east and west sides of Paradise. Mr. Dale, on the other hand, describes it throughout as a mica schist, assigning it a stratigraphic position far below the carboniferous. Portions of the slate are somewhat micaceous, but so are nearly all the carboniferous rocks of Narragansett Bay, this character being a necessary consequence of their derivation from the highly micaceous gneisses and schists surrounding and probably underlying this geological basin. Some of the mica in the slate may be indigenous, but we can find no evidence that it is mainly so. Much of the rock is no more micaceous than the slate of Easton's Point; and like that it contains numerous minute crystals of magnetite. This slate forms nearly all the lower ground, and to some extent the higher slopes from the conglomerate of ridge II to that of ridge VI. It has a steep westerly dip at all points, probably underlying the conglomerate on the west, and very clearly and conformably overlying it on the east. The contact is well exposed on the west face of Hanging Rocks, with several alternations of conglomerate and slate, showing a gradual passage from the one to the other, as on Easton's Point.

(3). Alternating with the slate in more or less regular bands, and forming the main masses of ridges III, IV and V, we have the third and most puzzling of the rocks of Paradise. It is a massive, greenish, crystalline rock, showing to the naked eye an abundance of chlorite (probably altered hornblende), iron oxide and feldspar.

This is the "amphibolic aggregate" of President Hitchcock, and the hornblende schist of Mr. Dale. All previous observers are agreed that it is a highly crystalline stratified rock; and its relations to the carboniferous strata have usually been explained as due to a series of strike faults. Mr. Dale, regarding the slate as also a crystalline rock, only requires two faults, as indicated in his general section; but Prof. N. S. Shaler,[1] referring the slate rightly, as we think, to the carboniferous series, is obliged to bound every band of the chloritic crystalline rock by two faults.

After reading Mr. Dale's paper, and before visiting the locality, we felt that the geological interest of Paradise centred in the nature and relations of this crystalline rock. Our first observations caused us to suspect that it could not be a stratified rock, and we were soon confirmed in this opinion. The rock is perfectly massive, showing absolutely no traces of bedding, but presenting just the aspect of an altered though distinctly crystalline trap or greenstone, and resembling many of the altered diabases of eastern Massachusetts. In proof of its eruptive nature we will present, first, the purely lithological evidence. Mr. George P. Merrill, of the U. S. National Museum, has kindly prepared and examined sections of typical specimens from these crystalline masses. He reports:—

"The rock is undoubtedly an eruptive; but I am inclined to call it *diorite* rather than *diabase*, although the alteration has been very great and the silicates of iron and magnesia have been almost completely changed into the inevitable viridite and epidote. The remaining outlines are, however, plainly those of hornblende; and in a few instances I was able to obtain clinopinacoidal extinctions of 12°–15°, which point conclusively to hornblende. It is, of course, possible that this hornblende may itself be secondary, and that the perfectly fresh rock would show augite; but this does not seem probable. The plagioclase is decomposed, muddy and opaque; but it still shows twinning striæ distinctly enough to demonstrate its triclinic character. Titanic iron is abundant, and shows most beautifully the characteristic alteration to a gray, amorphous product (leucoxene?). Apatite is common, but no magnetite was observed."

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[1] Am. Nat. VI, 616.

We searched for contacts with the slate and found them at many points. The crystalline rock forms masses (dikes) forty to one hundred feet in width and approximately parallel with the slate in strike and dip. We found several places, however, where the contact turns abruptly and runs into and across the slate for short distances. The general parallelism of the two rocks is due to the facts that the slate is nearly vertical and very fissile, splitting readily in the direction of the bedding. At some points the slate is distinctly contorted and indurated near the contact; although for the most part it shows little alteration. The crystalline rock, on the other hand, is always most coarsely and distinctly crystalline in the middle of the dikes, and becomes very fine grained or compact near the slate, in some cases showing a concretionary or toadstone structure along the contact. In no instance did we discover the slightest indication of a passage from the dike rock to the slate, but the two are always separated by a perfectly sharp and definite line. The structure and relations of the dikes are most clearly exposed at a point near the southern end of ridge IV, where an excavation has been made across one of the dikes, exposing perfectly its entire breadth and both walls. Perhaps the most convincing proof that the crystalline rock is eruptive in the slate is that afforded by the general arrangement of the dikes. We have made out six great dikes, or two each in ridges III, IV and V. In the last two ridges the exposures are almost perfect, so that the dikes can be traced continuously for considerable distances; and we have found that the two dikes of ridge IV, which are separated at most points by at least one hundred feet of slate, converge southward and finally unite, the intervening slate being entirely cut off. The same phenomenon is observed in following the dikes of ridge V northward. These ridges partake of the branching or composite character of the dikes, and are not readily distinguished at all points. It is very clear, however, that, as ridges I, II, VI and VII owe their existence to the superior resistance which the quartzite conglomerate offers to the agents of erosion, so ridges III, IV and V are due to the fact that the enclosing slate has been largely worn away, leaving the edges of the dikes protruding in jagged, blade-like crests. The slate belts are from one hundred to three hundred feet in width, forming the floors of the valleys and the slopes of the ridges in the more protected places, and the total breadth of slate and trap, from the conglomerate on the west to that on the east, is about 1200 feet.

On the south, the dikes, like the ridges, are cut off abruptly by the waste of sand separating Paradise from the sea. Toward the north, the ridges gradually descend, and die out at a distance of from a mile to a mile and a half, the dikes continuing until lost beneath the drift, and probably much farther.

Having shown that the massive crystalline rock is eruptive, of course no faults are required to explain its relations to the enclosing carboniferous strata, and the Paradise section is greatly simplified. Advancing from the west we find that the normal anticline of Easton's Point is followed by a nearly normal syncline in the high conglomerate ridges I and II. The slate that passes below this syncline on the west reappears near the base of ridge III on the east and—omitting the dikes with their salient outcrops, ridges III, IV and V—forms the floor of a broad level valley, extending with a nearly constant westerly dip to the base of ridge VI (Hanging Rocks), where it apparently overlies the conglomerate ; but reappears from beneath the conglomerate with the same westerly dip on the east side of ridge VII. Since we are obliged to regard the conglomerate on the east and west of Paradise as the same, the conclusion cannot be resisted that the broad area of slate between ridges II and VI forms a closed and somewhat overturned anticline, while the conglomerate of the Hanging Rocks and ridge VII forms a similar closed and unsymmetrical syncline, the slate passing beneath it and reappearing on the east.

In other words, it is clear that, regarding only the stratified rocks, Paradise would consist of two high and complete synclines of conglomerate and slate—an open syncline on the west and a closed and inverted syncline on the east—with a broad, inverted anticlinal valley or floor of slate between. Then we have simply to conceive this deeply eroded anticline of slate as traversed by about six immense dikes forming the remaining ridges, to complete the picture of Paradise as it actually exists. The discovery of the great dikes of Paradise destroys the generalization which we had previously made that the carboniferous strata of New England, although showing everywhere enormous disturbance, are not traversed by eruptive rocks.

GENERAL MEETING, OCTOBER 20, 1886.

Vice President, Mr. F. W. Putnam, in the chair.

The chair announced the deaths of Mr. James A. Dupee, a Life Member since 1854; of Col. Charles Whittlesey of Cleveland, Ohio, a Corresponding Member; and of Miss Lucretia Crocker, elected an Associate Member in 1876 and a Corporate Member in 1885.

Professor Hyatt said :—

Mr. President :—

The lady to whose death you have called the attention of the Society had become, through association in educational work, my intimate professional friend. During the past ten years she has been one of the persons to whom I have looked for advice and aid in our educational work, so far as it related to the public schools and to our Museum in some of its connections. During all this time she has never refused her assistance and has repeatedly volunteered in doing onerous tasks for our benefit. I, therefore, offer these brief remarks, not only in my official capacity, but, also, with a deep sense of the personal loss of a true friend and tireless associate.

Miss Lucretia Crocker, in the course of a few brief years of public life, won her way to the respectful consideration of every man with whom she came in contact, on account of the purely impersonal and professional soundness of her mind and judgment. Among women, these qualities, her sympathy with all good works, her personal sacrifices in the cause of education, and her unswerving devotion to this work made her a leader of commanding ability. Her course in connection with this Society has shown the same consistent devotion to a cause, as elsewhere. She has perpetually sought to fill her proper sphere, quietly and without publicity, indifferent to the fate of her own name, provided certain aims were accomplished and a definable progress in education attained.

Miss Crocker never gave a scientific communication, was rarely present at the meetings of this society, and therefore remained comparatively unknown to a certain portion of our members, nevertheless, she belonged beyond question to that small class of persons whose memory we shall always especially honor.

During her ten years of membership and for several years previous to her election, she was a frequent visitor in this building, and the Society's power of doing useful work was sensibly enlarged by her efforts during this time. Immediately after election to the Board of Education of this city, she took up the natural sciences, believing that through them much might be done for the reformation of the existing systems of education. She became first a pupil and then an earnest friend and indefatigable co-worker in the Teachers' School of Science. The continuance of this school, in 1878–79, was due to her unsolicited intercession with Mrs. Hemenway and Mrs. Shaw, from whom she obtained the funds to pay for the lessons given during that winter. No permanent results followed however; no lessons were given during the following season of 1879–80. The school might have temporarily ceased to exist, but for the united and voluntary exertions of Miss Crocker and Mrs. Hooper. They solicited subscriptions from the ladies of Boston and worked with such success, that one of our most efficient years was perhaps the winter of 1880–81.

Miss Crocker's connection with this department was not confined, however, to the simple office of obtaining means to keep it alive. As supervisor in the public schools of Boston, she became well acquainted with the needs of teachers and used her influence to urge them on to the attainment of a higher culture in natural history. She also used her knowledge to make frequent suggestions with regard to the selections of subjects for the courses, and these were almost invariably such as we could approve and follow with advantage. During the last fourteen years she was present every Saturday afternoon, almost without fail, and, when needful, spent the greater part of the day in our lecture rooms. It therefore goes without saying that she looked upon this as a very important part of her work in the public schools, and unfortunately it is also easy to perceive, that her death may sensibly affect the immediate prosperity and future usefulness of this department.

These facts, however, do not by any means represent the whole value of Miss Crocker's life to the Society, nor the loss it has suffered in her death. She was also deeply interested in the progress of the Museum and had fully entered into and sympathized with its plan of work. Her power and influence were very large. She had gained the confidence of many persons and was well known to the public, and she had promised to place herself at the service of this department whenever the proper time should arrive.

I do not feel qualified to speak with regard to the work of Miss Crocker in the public schools, but one thing has seemed very evident, even to me, that it was certainly largely, if not almost wholly, due to her, that natural history has assumed so prominent a place in the curriculum.

With regard to another chapter of her work in the public schools, Mrs. Richards has, at my request, written a short communication which I will read as a fitting conclusion to these remarks.

"Miss Crocker, while not a specialist, had the rare quality of mind which permitted a wide acquaintance with various branches of elementary science and a judicial balancing of the claims of each. It was this faculty which made her so well qualified to suggest to specialists appropriate ways of teaching science from the educational standpoint and not from the technical or professional one.

"Her judgment as to the essential points in any science which could be made of value to children and youth as a part of their education, was almost unerring. Her influence in this direction can never be fully known but we may select a few instances. She was the first organizer, in 1872 or 1873, of the science department of the Society to Encourage Studies at Home. She was a member of the Woman's Educational Association, and, although rarely present at their meetings, was really foremost in all movements pertaining to scientific education for women. We never did anything in opposition to Miss Crocker's judgment, and her approval was sufficient to insure the success of whatever we undertook.

"Of her own especial work among the teachers and in the schools one instance will suffice to show her scientific method. Miss Crocker, in the year 1881–82, asked me to join with her in giving a series of First Lessons on Minerals for the use of the public schools.

For two years we met at the appointed hour and together gave the lessons, some 125 in all, in twelve schools. Miss Crocker was not only critical and suggestive in our discussion of the lesson, but while she wrote on the board the children's answers to my questions, she supplemented and modified my work in a marked degree, thus bringing into the course all the experience which she had gained. It was this practical quality in the instruction which made the lessons so successful as models of elementary scientific teaching; nevertheless she refused all credit for the work done. From many quarters she gathered ideas on special topics, selecting and combining whatever could be made of use into an harmonious whole for the use of the public schools.

"I think I may truthfully say that no educational work of public importance has been undertaken in Boston since 1871, without Miss Crocker's interest and counsel.

"We have lost not only a friend, but an inspiration."

It was voted that the Secretary express to Miss Crocker's family the Society's sympathy in their bereavement.

The following paper was read:—

LOCALITIES OF QUARRIES WORKED BY THE INDIANS FOR MATERIAL FOR THEIR STONE IMPLEMENTS.

BY HENRY W. HAYNES.

For some time past I have occasionally found in different Indian shell-heaps and village-sites along the north shore of Massachusetts Bay, implements and flakes made of a compact, unicolored felsite, of a light green color. It has been a matter of some interest to me to discover, if possible, the locality from which this handsome material was obtained. No specimens of it are to be found in our own mineralogical collection, and there are none at Cambridge; and our local mineralogists could not give me any clew to it. Last summer, however, I succeeded in finding a spot where it occurs in large quantities, and where manifest traces appear of its having been extensively worked in former times. The soil in the immediate vicinity is filled with chips and broken fragments, many of which, by their disintegrated condition and weathering, show marks of great antiquity. The locality is a hill in Melrose, about a quarter of a mile northeast of Wyoming Cemetery. I have brought specimens of the mineral and flakes made of it, together with several implements fashioned out of it, which I have found in different places.

Another substance much employed by the Indians, and found both in the shape of implements and of flakes in similar situations along the north shore, is the so-called "Saugus Jasper." This is not a true jasper, but a compact, non-porphyritic petrosilex, of a light red color. It occurs only in a small outcropping on the south side of the Saugus River, a short distance to the northeast of the railroad station at Saugus Centre. For many rods around the ground is filled with fragments, and there can be no reasonable doubt that the quarry was worked for a very long period. This locality is about two miles distant in a northeasterly direction from the place where the green felsite occurs. I have specimens of it here for your inspection, as well as implements made of it from various sites.

The most common material, however, used by the Indians of this vicinity for the manufacture of their stone implements, is the porphyritic felsite, which occurs abundantly in Lynn, Saugus and Wakefield. It is of a dark brown or chocolate color, speckled with grains of white quartz. I have here implements made of it, selected out of a much larger number, which I have found in many places quite widely separated from each other. All the implements exhibited here are marked with the names of the localities where they were found. The spot, where the outcroppings of this material seem to have been most worked by the Indians, so far as my information goes, judging from the number of implements that have been found in the immediate vicinity, and the fragments with which the hillsides above are covered, is in the extreme southeasterly corner of Wakefield, in Greenwood. This is the same locality where Mr. David Dodge discovered those "rude implements of a palæolithic form," which were exhibited at the meeting of this society on Jan. 5, 1881.[1]

Upon a former occasion I referred to investigations made by me in certain Indian shell-heaps on the shores of Frenchman's Bay, in the island of Mt. Desert, Maine.[2] The stone implements found in them are generally fashioned out of a compact, green felsite, speckled with grains of milky or transparent quartz. Boulders of the same material are common upon the neighboring beaches. A year ago, on a visit to Mt. Kineo, Moosehead Lake, in Maine, I found that the mountain is entirely made of the same kind of rock. Evidently it was well known to the Indians as a source of supply of the material for their implements, as was manifest from the abundance of the refuse pieces to be found there. In the fields at the foot of the mountain and near the hotel I found numerous examples of their manufactured articles, which show by the thick patina of their surface that a very long time has elapsed, since they were fabricated. Some of these I have brought here for your inspection.

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[1] See Proc. Bost. Soc. Nat. Hist., Vol. XXI, p. 123. *cf.* Fifteenth Rept. Peabody Museum, p. 57.

[2] See Proc. Bost. Soc. Nat. Hist., Vol. XXII, p. 60.

Another interesting locality, from which the Indians procured material of a similar character, is the so-called "Jasper Cave," in Berlin, New Hampshire. This spot also I visited a year ago, and I have brought here specimens of the mineral broken from the roof of the cavern. This, also, is not a true jasper, but a petrosilex, striped and mottled with brownish-red and yellow. It is of a handsome appearance, breaking readily with the conchoidal fracture, and is excellently adapted for making arrowheads and other fine work. The "cave" was discovered only so recently as 1861, and is situated on a rocky ridge about a mile and a half west of the village. It is found in a vein of metamorphic, silicious rock, which cuts through a mass of micaceous hornblende schist. The entrance to it is just large enough to crawl through, and conducts by a narrow passage seven or eight feet long into an excavation about thirty feet in length, by from six to eight feet high and wide. The material here obtained was carried by the Indians about seven miles up the Androscoggin River to a site in Milan Corner. There, traces of their village can be found upon a broad terrace, about thirty rods from the west bank of the river, on the farm of Mr. Sumner Chandler. Innumerable flakes of the "ribboned Berlin Jasper" fill the soil, and many implements made of it have been found there. Several of these flakes I have brought here, which show great changes in texture and color, occasioned by long-continued atmospheric influences.

But of all the localities in the United States from which the Indians procured the material for their stone implements, by far the most celebrated is the so-called "Flint Ridge," situated in

Licking and Muskingum Counties, Ohio. This has been recently described with great minuteness by Mr. Charles M. Smith in an article published in the Smithsonian Report for 1884, part I, p. 851, to which I refer you for complete information in regard to it. I have, however, brought here specimens of the material and implements manufactured from it, thinking it may be of interest to you to compare them with the materials used for similar purposes by our New England Indians.

General Meeting, Nov. 3, 1886.

The President, Mr. S. H. Scudder, in the chair.

The following Associate Members were elected: Mr. Arthur P. Chadbourne of Cambridge; Mr. H. W. Conn of Middletown, Ct., Miss Edith W. Cushman of Cambridge and Mr. John C. Gray of Boston.

Mr. James H. Emerton described the anatomical development of the milk-weed butterfly in the pupal stage, concerning which he had a paper in preparation. Mr. Emerton also spoke of the habits of flying spiders, which are especially abundant on Boston Common.

Mr. Scudder showed a piece of fossil juniper wood from interglacial deposits near Toronto, showing borings of beetle larvae, belonging to four different families.

Mr. Putnam spoke of the destructiveness of the large water bug Belostoma in carp ponds, where young carps are destroyed by hundreds. It is hoped that by the use of the electric light, which attracts these bugs in great numbers, they may be gradually exterminated.

A fine skeleton of a baboon, Cynocephalus porcarius, from Sierra Leone was presented by Mr. Holmes Hinckley.

General Meeting, Nov. 17, 1886.

The President, Mr. F. W. Putnam, in the chair.

Prof. G. L. Goodale gave an interesting account of Professor Pfeffer's recent investigations showing that coloring matter can be absorbed by living vegetable cells, and the bearing of this discovery on various questions in vegetable physiology.

Professor Hyatt showed a cast of a femur of Atlantosaurus, a gigantic Jurassic Dinosaur perhaps eighty feet long, presented by Professor O. C. Marsh to the Museum. The thanks of the Society were unanimously voted to Professor Marsh for this valuable gift.

SECTION OF ENTOMOLOGY, NOV. 24, 1886.

The President, Mr. S. H. Scudder, in the chair.

Mr. J. H. Emerton showed the nest of Atypus Riversi of California, which has a tubular entrance projecting an inch or two above the ground. He also showed a collection of the family Ciniflonidae, with drawings of some of the species to illustrate a monograph of the group soon to be published, and described the characteristics of the principal forms.

Mr. S. H. Scudder spoke of the conflicting evidence regarding the introduction of Pieris rapae. It probably first appeared in Quebec in 1860 and spread into New England in 1865, working to the southern part in four or five years.

Miss C. H. Clarke showed specimens of Ptinus fur, which had been living in a box of red pepper over a year.

GENERAL MEETING, DEC. 1, 1886.

The President, Mr. S. H. Scudder, in the chair.

The President announced the death of Capt. N. E. Atwood of Provincetown, a corresponding member since 1847. Mr. F. W. Putnam was to have given some account of Captain Atwood, but being unable to be present has since sent the following notice.

“ Those among us who remember Captain Atwood a quarter of a century or more ago, when he so often spoke to us from the vast store of facts which he had gathered during his life as a fisherman and sailor, will always remember our dear old friend and his kindly ways. Whenever he was seen to enter our meeting-room we were sure that there would be no dearth of material for an instructive evening. Often he would come prepared to speak about the habits of some fish well known to us by name and taste, or perhaps about the lobster and the changes he had observed in that fishery, or about the giant cuttle-fishes of the north, or the whales and other cetaceans he had seen before the modern methods of capture were introduced. Such an evening was sure to bring out fact after fact from our veteran fisherman, as question after question was asked. He was by nature an accurate observer and, following the sea from his boyhood, he had ample opportunity to use his powers. When he became his own master these observations were of practical value to him and he based his fishing ventures upon them. This love for natural history made him in every way a broader, grander man than he otherwise naturally would have been. It led to a desire for more knowledge and to a self-cultivation which had its reward in the close association he had with such men as Storer, Gould, Wyman, Agassiz, and other leaders in our Society, to all of whom he gave information, and by whom he was encouraged in his studies. It secured to him the respect of his neighbors so that they sent him to the state legislature, and he also most worthily occupied the platform of the Lowell Institute. When the state legislature, in 1856, appointed a commission to investigate the artificial breeding of fish with a view to restocking our rivers, Captain Atwood was one of the three appointed, Judge Chapman and Dr. Wheatland being the others, and to him fell the honor and the labor of carrying on the first fish-hatchery in our state. It is a singular coincidence that I was an invited guest at Captain Atwood's house at Provincetown at the meeting of this commission, and am now a member of the state board which resulted from these preliminary experiments. Well do I remember the house upon the Point, with the glass in its windows ground and cut through by the driving sands ; and while all was flying sand and spray without, my boy's heart then and there, in the snug dining room, went out to the kind, and to me then old, man, and ever since he has been cherished as a friend, and now his memory will be dear to me as I know it will be to all who had the good fortune to know him."

Mr. S. R. Bartlett gave a brief review of Ranvier's researches on the salivary glands of the Mammalia.

Mr. W. L. Harris exhibited a living Amblystoma from Wilmington, Mass., apparently new to our fauna ; and another species, A. mavortium, from Iowa. Mr. Harris also showed a pale pinkish specimen of our common Massachusetts newt of adult size, but bearing well developed external gills.

Professor W. T. Sedgwick spoke of the excretory contractile vacuoles of Paramoecium. Ray Lankester's figures descriptive of the progress of diastole and systole are quite faulty and their true character was shown by drawings and diagrams.

General Meeting, Dec. 15, 1886.

The President, Mr. S. H. Scudder, in the chair.

Dr. E. G. Gardiner sketched the history of our knowledge of the pineal eye in lizards, and reviewed a recent paper on the subject by Mr. W. Baldwin Spencer, in the Quart. Journal Micr. Sc., Oct., 1886.

Prof. W. M. Davis presented the results of a study on the mechanical origin of the Triassic monoclinal in the Connecticut Valley. The present attitude of the Triassic formation in the Connecticut valley may be described as a faulted monoclinal; the dip is nearly always eastward, fifteen to thirty degrees, but the continuity of the strata is interrupted by the occurrence of numerous faults, running nearly parallel with the strike of the beds, and with upthrow of variable amount on the east. The formation is thus divided into long, relatively narrow blocks trending from west of south to east of north, the strata in all the blocks being canted to the east. The repetition of beds, caused by the upthrow of the faults, is always on the side of the direction of the dip, and thus allows a moderate thickness of strata to cover a broad surface, greatly simplifies the scheme of eruptive action by correlating many different trap ridges as the outcropping edges of only four or five trap sheets, and gives a systematic structural interpretation to a complicated topographic form.

The mechanical origin of the faulted monoclinal offers an interesting problem for investigation. It cannot be referred to original oblique deposition, because heavy conglomerates occur on the eastern margin of the formation, dipping toward the ledges from which they were derived. A disturbance contemporaneous with the process of deposition is excluded by the occurrence of faults, which require continuity of their corresponding members across broad areas before the disturbance took place. The monoclinal attitude cannot be ascribed to the eruption of the trap; for the greater part of it was poured out conformably on the bedded rocks during their accumulation, and hence passively suffered disturbance at some later date: nor can the intrusive sheets have been the cause of the monoclinal; for the dip of the strata does not vary significantly on approaching the intrusions; and the topography of the intrusive trap ridges is so closely like that of the overflow trap ridges that the structure of both must be referred to a single cause; this implies that the intrusions as well as the overflows took place while the formation still lay horizontal, and that the whole mass of beds, igneous as well as aqueous, was afterwards deformed by some external force.

It is therefore suggested that the schists and gneisses, on which the triassic strata lie unconformably, may have suffered distortion by a lateral compression from east to west. In such case, one of the easiest ways of yielding to the crush would be by a slipping of slab on slab, whereby their inclination should steepen and their horizontal measure decrease. As slab slips on slab, the formerly horizontal bevelled surface of every one is canted so as to dip in one direction at an angle equal to the change of the inclination of the slabs; and the surface of every slab is separated from that of its neighbors by faults with upthrow on the side of the direction of dip. The triassic cover is not strong enough to bridge across from ridge to ridge of the uneven surface thus produced; its weight is much greater than its strength can bear, and it perforce follows the deformation of its foundation, and thereby acquires a faulted monoclinal attitude. The explanation of the triassic monoclinal may therefore be included in the following general statement. Wherever unconformable masses are deformed together, the structure given to the lesser, relatively superficial mass must depend in great part on the changes in the surface shape of the greater, deeper mass below. Since this explanation came to mind, the author finds that its essential feature has been distinctly stated by Gilbert, as affording some clew to the origin of the faulted mountain ranges of the Great Basin (Wheeler's Surveys West of 100th meridian, vol. III, 1875, 62).

The tests thus far applied to this hypothesis are satisfactory, inasmuch as they correlate structures that were not before perceived to be dependent on one another. The strike of the surface faults corresponds with the strike of the schists beneath, as far as has yet been determined. The attitude of the fault-line with respect to the trap ridges gives systematic explanation of the order of overlap of successive ridges heretofore unexplained. Several other tests of the hypothesis have come to mind but have not yet been applied in the field.

General Meeting, Jan. 5, 1887.

Vice President, Mr. F. W. Putnam, in the chair.

The following Associate Members were elected: Mrs. Ella F. Boyd, Mrs. Emily A. Pigeon and Messrs. Chas. C. Doe, James Means, George H. Parmelee, Loring Wm. Puffer.

Mr. Putnam gave a very interesting account of the explorations made by Dr. Chas. L. Metz and himself during the past summer in the mounds and burial places of the Little Miami Valley, and exhibited a series of photographs showing the successive stages of excavation and the exact position of the skeletons and objects found.

General Meeting, Feb. 2, 1887.

The President, Mr. S. H. Scudder, in the chair.

Dr. J. S. Kingsley discussed the segmentation of the arthropod egg, and the origin of the mesoderm.

The President read a letter from Prof. R. H. Richards accompanying a curious fungoid growth from a zinc mine, called the Buckwheat mine, in New Jersey.

General Meeting, Feb. 16, 1887.

The President, Mr. S. H. Scudder, in the chair.

Dr. Thomas Dwight read a paper on the range of variation in the human shoulder blade. (See American Naturalist, 1887.)

Prof. Wm. Trelease presented a monograph of the Geraniaceae which will appear in the Memoirs, Vol. iv.

GENERAL MEETING, MARCH 2, 1887.

The President, Mr. S. H. Scudder, in the chair.

The President announced that he should decline reëlection at the next annual meeting, when he will have completed seven years of service. He suggested, that it would be for the interest of the Society to make the office an annual one, and he hoped that the members would consider this question carefully.

Mr. L. P. Nash was elected an associate member.

The President then introduced Mr. C. D. Walcott of the U. S. Geological Survey, who gave an account of a "Trip through the Grand Cañon of the Colorado." Mr. Walcott illustrated his remarks by showing many lantern pictures, presenting to the Society a continuous view of the geology of the Grand Cañon, which he has done so much in elucidating.

Mr. J. H. Emerton described the restoration of the skeleton of Dinoceras mirabile.

Soon after the publication of Prof. O. C. Marsh's monograph of the Dinocerata the speaker began a restoration of the skeleton of Dinoceras mirabile which has just been finished and copies mounted in the Yale College Museum and the Museum of Comparative Zoology in Cambridge.

The collection of Professor Marsh contains portions of nearly every bone in the skeleton of Dinoceras, but these belong to many individuals of all sizes and proportions, so that few parts of the restoration could be cast directly from the bones, the rest having been modelled in clay.

The size of this restoration was determined by the bones of Marsh's type specimen of D. mirabile. These include a nearly complete skull only slightly distorted, the pelvis, lumbar vertebrae, one vertebra of the neck and two ribs, plaster casts of all of which have been made and distributed to various museums.

No complete vertebral column has been found, so that the number of vertebrae is uncertain, and the number made is the same as found in the horse and tapir and in the elephant to which the Dinoceras appears nearly related. There are several sets of vertebrae in the collection from different parts of the column from which the form of all can be copied, except those in the middle of the back which are modelled from a few fragments. The lateral processes of the lumbar vertebrae have been restored in shape following the same bones in the hippopotamus. The posterior half of the sacrum of the type of D. mirabile is wanting and has been restored from other specimens.

There are several vertebrae from different parts of the tail, so that the shape is tolerably certain, though the number of vertebrae is unknown.

There are very few complete ribs in the collection, and excepting the first pair the exact place of none of them is known. All the ribs had to be modelled from fragments of which there are several hundred from ribs from all parts of the body.

The left fore leg is cast from bones of three individuals which appeared to be of nearly the same size as the type of D. mirabile, and the right fore leg is a reversed copy of it. The right femur is cast from a bone and the left copied from it. Both tibiae are modelled from one from a smaller skeleton, the proportions between the bones having been measured from the specimens belonging to smaller individuals.

The feet are modelled from a large number of bones, among them a nearly complete hind foot and fore foot of a smaller size than the model.

The whole model is made of paper cast in plaster moulds. The supporting frame is of gas pipe concealed in the model.

The following paper was read:

ON THE USE OF THE NAME TACONIC.

BY JULES MARCOU.

If priority is to be adhered to strictly and above all other considerations, it is in natural history; for, without it, zoology, botany, palaeontology, mineralogy and lithology, would become a confused and almost valueless mass of documents. All *savants* without regard to nationality, schools, or personal inclination, now place priority first; and a naturalist who disregards it is sure one day or another, to be severely judged. Justice requires it, classifications require it, museums require it, libraries require it, bibliographies require it; and, finally, progress of science, will be impossible without it.

Questions of priority are matters of printed facts, and the greater caution and exactness are required to establish them on a solid basis. Often, I will say too often, an author unintentionally and with great honesty of purpose, thinking the matter of little consequence, quotes loosely and out of date, inexact synonymy, or gives precedence to publications and names, which are in fact posterior and consequently placed in wrong positions.

The memoir of Mr. Walcott, "Second Contribution to the Studies on the Cambrian Faunas of North America" (Bulletin U. S. Geol. Surv., No. 30, Washington, 1886), is too important, and he is too desirous "to establish," as he says, "on a firm stratigraphic and palaeontologic basis, the Cambrian system of the continent," not to help him by pointing out errors in " these preliminary studies," as he calls them, adding candidly that he "will be glad to have his attention called to them."[1]

It is in answer to his demand that I will call his attention, first, to " the use of the name Taconic ;" and later, in another paper which will promptly follow, on " the Taconic of Georgia, Vermont." Mr. Walcott has a long explanation entitled : "On the use of the name Taconic," in his " introductory observations" (see pp. 65 to 71), where he tries to show why he is " compelled to use Cambrian in preference to Taconic."

Mr. Walcott says that the fauna published in "his paper is the fauna of the Upper Taconic of Emmons as defined by him in 1855 ;" moreover, he admits that "Dr. Emmons was correct in classifying the Upper Taconic as Pre-Potsdam ;" and further he says that " Dr. Emmons deserves great credit for the work that he did." Yet notwithstanding all these friendly admissions of the discovery and value of the Taconic system, and the singular statement that the lower division " will be dropped entirely ;" and that " the Upper Taconic which," according to Mr. Walcott, "is not now known to occur in the Taconic area, would be taken as the true Taconic, which it does not appear to be, although Dr. Emmons included the *Black Slates* in it in 1847 ;" farther on he adds, "it is one of the misfortunes of his (Dr. Emmons) career that he began his work on the Taconic system in the Taconic area, instead of Western Vermont or along the Hudson river, etc." Emmons, on the contrary, ought to be highly complimented, because he first worked out, in a difficult part of the country, the arduous and most important problem of finding an immense system of strata below the Potsdam, collecting stratigraphic and palaeontologic proofs at and near the Taconic range. The name is excellent in all respects, being indigenous, a beautiful Indian denomination, indicating a range of mountains well defined, where the first observations were made, and is as appropriate as the Jurassic, from the Jura mountains.

As to the Taconic area not being truly Taconic, and " that most, if not all, of the strata included by Emmons in his original Taconic are of Lower Silurian age," Mr. Walcott, by his own researches of 1886, knows now that these are only erroneous notions put forward by the "united opposition of Emmons' contemporaries."

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[1] Second Contribution to the Studies, etc., on pp. 58, 59 and 65.

The use of the name Taconic is a very simple question. It rests entirely on priority. Barrande has demonstrated, as far back as 1861, that it was in the Taconic system, that the primordial fauna was first discovered in 1844, and, consequently, that the American name has precedence over all other names.

It is a creed among geologists, a creed which has just received a new sanction and acknowledgment at the meeting of the Commission for the uniformity of nomenclature of the International Geological Congress at Geneva, in August last, that no system of stratified rocks is accepted as independent and separate, unless it contain a special fauna. Sedgwick did not find a single fossil in the lower part, of what he called, in 1835, the Cambrian system, and he had no right to include it in the Cambrian. We have there two systems of strata as well marked and separated as any of the different systems in existence in our classifications.

The Taconic system is the only *Terrain* or division of the second order that can be claimed by American geologists in the general classification of the strata of the world; and to surrender it it into the hands of the English is to give up the only claim we have to be recognized as original discoverers. Certainly, we shall preserve also all the classifications of the divisions of the third (divisions), fourth (groups) and fifth (beds), orders special to America; and on that account there is not the smallest danger to be apprehended of their being suppressed or superseded by European geologists. But it is a patriotic duty for us Americans to preserve and keep religiously, the fact that here, among the mountain ranges which separate the Hudson river and Lake Champlain from the Connecticut river and the Green mountains, the great system, containing the Primordial fauna, was first discovered, pointed out and named.

Mr. Walcott uses repeatedly the name Ordovician as a synonym or substitute for Lower Silurian (second fauna) confining the name Cambrian to the Taconic or Primordial fauna horizon. It is an unfortunate introduction of a very recent name, for strata well defined and named in America many years previously. Doctor Emmons in his remarkable classification of the Palaeozoic strata of the State of New York in 1842 and 1846,[1] called "Champlain division," almost all the strata containing the second fauna; very little alteration and correction are wanted to place it in harmony with the other great palaeontologic and stratigraphic systems. He says, that like the divisions adopted in the Reports of the Geological Survey of New York, he proposes to subdivide the New York system of rocks, by employing geographical names which he had found useful geologically,—certainly an excellent principle used everywhere.

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[1] Geology of New York, Part II, p. 112, and Agriculture of New York, Vol. I, p. 115. Albany, 1842-46.

The name Champlain was used by de Verneuil in his celebrated *Note sur le parallelisme des roches des dépôts paléozoiques de l'Amérique septentrionale avec ceux de l'Europe*, etc. (Bulletin Soc. Géol. de France, tome IV, p. 646, 19 April, 1847, Paris), as a synonym for the Lower Silurian, and ever since, in numerous publications made in the United States, in Canada and in Europe, the name, first given by Dr. Emmons, has often been employed and his meaning is well understood.

In 1879, Professor C. Lapworth, impressed with the fine palaeontological classification of the Lower Palaeozoic rocks, by Barrande, into Primordial, Second and Third fauna, and desirous of effecting a sort of compromise between Sedgwick's, and Murchison's, classifications, proposed the name Ordovician, from Ordovicia the northern portion of Wales, for the rocks containing the second fauna, instead of Upper Cambrian of Sedgwick, Lower Silurian of Murchison and Cambro-Silurian of Jukes. (On the Tripartite Classification of the Lower Palaeozoic Rocks, in Geol. Mag. January, 1879, Dec. II, Vol. VI, London.)

In making such a proposition Professor Lapworth ignores all previous classifications made out of Great Britain. He not only puts aside all questions of priority, but does not comply with the law that a system cannot be accepted if it was not, at the time of its discovery, characterized by a special fauna. In fact the proposition is made against all laws of priority, of palaeontological evidence, and without any regard to the numerous works and important discoveries made in America. That any American geologist should accept such a proposition, and let his right not only be infringed, but even overlooked, is so surprising, that it will suffice to point it out.

Our strata have not been studied and classified by Englishmen, nor even by Canadians. All our researches stand by themselves without the aid of Murchison, Sedgwick and other British writers. Our geology is as great as our country; and European geologists are ready to recognize the part taken by American geologists. At the meeting of the International Geological Congress at Berlin, the Secretary of the Commission on the uniformity of nomenclature, Prof. G. Dewalque, made a report in which he says: "M. Jules Marcou, in an important work published by the American Academy of Science and Arts, and entitled "The Taconic System and its Position in Stratigraphic Geology," has vindicated the priority of the term *Taconic* of which the *Cambrian* above mentioned (or Primordial fauna) would be the equivalent. To us the question seems to be demonstrated. In such a case the term Cambrian should be employed to replace the Ordovician, the name Silurian should come back by right to group 6. If we be not in error, this solution would avoid many difficulties. We propose, then, to the Congress to determine first, the names that the groups 4, 5 and 6 should bear. It will afterwards have to decide whether they constitute one or two systems; and, finally, the name or names to be employed."

"Dr. A. Geikie proposed that the Congress postpone the subject of subdividing the Cambrian and Silurian until the meeting in England; on the ground that the Silurian question was mainly an English question. (Loud murmurs.) Professor Hughes agreed with Dr. Geikie as to the propriety of postponing the discussion of these questions, and said that Professor Hall had also expressed his approval of this course."

"The chairman, Dr. von Dechen, put the question to divide the Silurian, but leave the names till the meeting in England. Professor Capellini regretted such action, if it would postpone the completion of the European map. M. Hauchecorne said it would not, as the map would be completed without waiting for the determination of the names."

"The motion was then put and carried." (See "The work of the International Congress of Geologists and its committees," published under the direction of Persifor Frazer, page 24 and also pages 57 and 58, 1886, no place of publication.)

From this quotation it seems that two English geologists, Mr. A. Geikie representing the Murchisonians and Mr. T. McKenny Hughes representing the Sedgwickians, backed by an American geologist, Mr. James Hall, representing "the united opposition of Dr. Emmons' contemporaries," succeeded in preventing the Berlin's International Geological Congress from voting and rendering justice to our just claim of having first recognized the Primordial fauna and first named the Taconic system. The vote in favor of the Taconic would have been carried by a large majority, according to the proposition made by Prof. G. Dewalque as Secretary of the Commission for the uniformity of the nomenclature. To say that the Silurian is mainly an English question is an assertion, which the "loud murmurs" of the members present at the meeting have sufficiently disposed of as unjust. The question is cosmopolite and international, and all the geologists of the world have a right to investigate and express their views.

In this connection I shall call attention to "A geological map of the United States" by C. H. Hitchcock, published lately in the Transactions of the American Institute of Mining Engineers,[1] November, 1886, Vol. xv, p. 486, purporting "to illustrate the schemes of coloration and nomenclature recommended by the International Geological Congress." In that map Professor Hitchcock has anticipated the decisions of the Congress, in using the name Cambrian and placing under one system instead of two, the second fauna and the third fauna which is called Silurian. The Congress has postponed the subject of naming the Lower Palaeozoic rocks until the meeting in England in 1888. It has only accepted the groups numbered 4 (primordial fauna), 5 (second fauna), and 6 (third fauna); showing that the Congress was determined to have three systems, and not two as given by Mr. Hitchcock; and that the Geological map of Europe, for which the classification is made, is going on, according to M. Hauchecorne, without waiting for the determination of the names, but using only the numbers 4, 5 and 6.

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[1] In a foot note, p. 479 and p. 15 of the separate pamphlet accompanying his Geological map of the American Institute of Mining Engineers, Mr. Hitchcock says, "Bulletin No. 7, published by the U. S. Geological Survey, is entitled Mapoteca Geologica Americana, a catalogue of geological maps of America (north and south) 1752–1881, in geographic and chronologic order; by Jules Marcou and John Belknap Marcou, 1884. It professes to enumerate every geological map ever published relating to American geology, together with a brief statement of the circumstances attending its publication and various comments. Some of our statements given on previous pages are at direct variance with those of the Mapoteca, and more in accordance with the views of American geologists. Since this *chef d'œuvre* of Logan and Hall is not mentioned in the Bulletin, even by title, the publication must be compared to that celebrated performance of Hamlet where, owing to infelicitous circumstances, the part of Hamlet was omitted."

The title of this *chef d'œuvre* of Logan" is on p. 29, No. 59, of the Mapoteca, represented by the reduced maps or "index" as Logan calls it, on the scale of 125 miles to one inch, of the larger maps in eight sheets. That index, or *tableau d'assemblage* of the eight sheets maps, is absolutely identical with the large map: the same title, the same nomenclature, the same explanation of the colors, the same coloring, the same letters and Arabic numerals, the same geographical distribution of the group of rocks. The complaint of Mr. Hitchcock is an exaggeration of an insignificant oversight. The slip of paper on which the large map was written, was left in the drawer, containing the manuscript, and it was not found until too late for its insertion in the Mapoteca. A material oversight which happily does not affect the completeness of the Mapoteca.

As to the "statements" of Mr. Hitchcock "at direct variance with those of Mapoteca" they will be treated with details, giving all the dates and exact issue of the maps, volumes and pamphlets in my next paper on the "Taconic of Georgia and the Report on the Geology of Vermont."

It is to be regretted that an American geologist, against the decision of the Berlin Congress, has taken upon himself to anticipate and foreshadow what the Congress may accept as a solution; and more than that, has put aside all American claims of priority to name the great zone of the Primordial fauna. If Professor Hitchcock had said on his map and in the explanatory text that the colors and names were only provisionary (*provisoire*) as it is marked at the head of the "color-scale for the geological general map of Europe" (see at the end of Dr. Frazer's pamphlet on the International Congress at Berlin), it would have been more in accordance with the results arrived at by the Committee upon uniformity of nomenclature.

The following table expresses in a condensed way, easy to read, all the principal views entertained in regard to the classification of the Lower Palaeozoic rocks in Europe and America. All data refer to memoirs and works well known to all interested in the question. A list of them is subjoined.

At the beginning, geologic methods were defective, and the first observers, like Sedgwick, Murchison, Emmons and Barrande had to make their way, with more or less of accuracy, among problems entirely new; and in using tools which had been tried, until then, only on the more recent formations. That some mistakes were made is certain, and it is a wonder that they are no more numerous; human passion, personal rivalry and jealousy, also added to the already very complicated question. But now, we can be more just and give credit where it is deserved. Priority of discoveries must stand first, and pass before anything else; and it is for us to correct the mistakes and injustice of our predecessors and contemporaries. If we do not do it now, it will remain for our successors to give due credit to all the great discoverers and classificators of the history of our planet. It is simply a question of time.

The facts are now well exposed before the geologists of the world. The Transition rocks are divided into systems, as well separated, and as well characterized as the Secondary or Tertiary rocks. The existence of well defined systems among the strata containing the beginning of life on our planet is no more to be doubted or discussed; and the Palaeozoic series or era is now divided palaeontologically and stratigraphically into systems well defined and equal in value to any system existing in our nomenclature of the earth's history.

Sedgwick's Cambrian comprises two systems, whose individuality is now recognized and admitted by all observers. In one exists the Primordial fauna and in the other the Second fauna. Sedgwick did not find the Primordial fauna and ignored it altogether until the end of his researches in the field; on the contrary, he discovered and signalized the Second fauna and had it described by McCoy. These facts cannot be disregarded. They solve the question and put aside all the claims of right to name these two systems. To Sedgwick belongs the Second fauna and the rocks containing it; and there the name of Cambrian must be confined. The other system, containing the Primordial fauna, was first signalized and described in America, independently of Sedgwick and of other researches made in Europe. Barrande first recognized the great value of the Primordial fauna; characterized the forms of animals found in it, and its features, which have ever since been accepted and acknowledged everywhere. No better judge, consequently, than Barrande exists; and his opinion as to the priority and the importance of the discovery of the Taconic system containing the Primordial fauna must be accepted as a law, as solid as any law or rules made in geology. To Emmons belongs the other system of the primitive Cambrian of Sedgwick, and its name of Taconic must supersede Cambrian with its double meaning.

I will add that Emmons saw, in 1842, that the lower division of the Cambrian of Sedgwick was, rather more than a division of the third order, a system or great grouping of strata of the second order. He knew no fossils then, and had the merit of being, even stratigraphically, the first discoverer; finding and proving that the strata below the upper Cambrian form a true system, which is called the Taconic system. (See: Geology of New York, Part II, p. 163, Albany, 1842.)

So stratigraphically and palaeontologically Emmons has priority in calling all the lower rocks of the palaeozoic and base of the great series of strata, the *Taconic System*, referring them to a *system* and not to a subdivision of a system as Sedgwick wrongly did.

Murchison in claiming the rocks of the Second fauna — and even the greatest part of the Primordial fauna—as belonging to the Silurian, has committed precisely the same scientific error as Sedgwick, putting two systems into one. Palaeontology has put an end to the discussion and to the tendency of both Sedgwick and Murchison to monopolize two systems. It has found a solution creditable to the two adversaries, and at the same time to a third observer, Emmons, who without claiming anything, has found the Primordial fauna, the very base and first step of Palaeontology itself.

Ordovician is absolutely valueless and creates a confusion without any compensation. Its author has put it forward on the trivial objection that the two opponents — Sedgwick and Murchison—being both wrong, a new name was desirable; and Professor Lapworth chooses a Welsh name, without consideration of the claims either of foreign geologists or foreign geology. Priority was set aside, and without any regard to the name of Champlain group used in America since 1844 — a fact which he seems to ignore—he has not hesitated in offering as a solution of the difficulty, a new name whose only merit is in being British. American geologists know well what is meant by Champlain group or Trenton fauna, and to replace it now by Ordovician, when we try to give credit and approve the claims of the distinguished authors and pioneers of the discoveries made in the Lower Palaeozoic rocks of the world, cannot be allowed. There is confusion enough without it. Let us be content with the names offered in 1835 and 1844 by Sedgwick, Murchison and Emmons.

In fact, to Sedgwick we owe the *Cambrian*, limited to one fauna, proved by Barrande to be the *Second fauna;* to Murchison we owe the *Silurian*, limited to the *Third fauna;* and to Emmons we owe the *Taconic* comprising the *Primordial fauna*.

American geologists have the right of priority in the Taconic system, and also they have priority in the name of Champlain over Ordovician offered lately by the English.

TABLE SHOWING THE TRUE HISTORIC CLASSIFICATION AND ORDER OF DISCOVERIES OF THE LOWER PALÆOZOIC ROCKS.

	SEDGWICK. 1835–51–52–55.	MURCHISON. 1835–39–54–58–67.	EMMONS. 1837–42–44–55–60.	BARRANDE. 1846–51–52–57–58–59–60–61–80.	MARCOU. 1860–61–62–81–85.	LAPWORTH. 1879.	WALCOTT. 1886.
THIRD FAUNA.	Silurian system or Wenlock and Ludlow groups.	Upper Silurian.		Silurien supérieur Faune troisième.	Silurian.	Silurian.	Silurian.
SECOND FAUNA.	Upper Cambrian System, or Bala group; fossils found and signalized in 1835.	Lower Silurian; fossils identical with those found by Sedgwick in his Upper Cambrian.	Champlain group, with the Potsdam as the base. Fossils, 1837-42.	D. Etage des quartzites du Silurien Inférieur. Faune seconde. Colonies.	Cambrian.	Ordovician.	Ordovician or Lower Silurian. Second fauna of Barrande or the Trenton fauna.
FIRST OR PRIMORDIAL FAUNA.	Middle Cambrian or Festiniog group. A few *Graptolites* and *Lingula* found and described in 1851-52. Lower Cambrian or Longmynd and Bangor groups. No fossils.	Primordial or Lower Silurian rocks. 1854. In 1867, Murchison concedes as Cambrian rocks, only the Longmynd, but claims the Primordial zone as Lower Silurian.	Taconic System. No fossils yet in 1842. In 1844, fossils are found and described as a special fauna; *Atops* (*Conocephalites*); *Elliptocephala* (*Olenellus*) and *Diplograptus*. In 1855, the number of fossils is increased; and in 1860 Emmons regards the Upper Taconic as the Primordial zone of Bohemia.	C. Etage des Schistes protozoïques du Silurien Inférieur, 1846, the term "Primordial fauna" is used and explained. 1861, Barrande says: "it is clear that Dr. Emmons has first announced the existence of a fauna anterior to that which has been established in the *Silurian system.*"	Taconic System. In 1860, Marcou puts the Potsdam in the upper part of the Taconic. Colonies. In 1885, three faunæ divide the Taconic. 1st, the Supra-Primordial = *Dikelocephalus* zone; 2d, the Primordial = *Olenellus* and *Paradoxides* zones; and 3d the ante- or Infra-Primordial zone.	Cambrian.	Cambrian divided into Upper Cambrian = Potsdam or *Dicellocephalus;* Middle Cambrian = Georgia or *Olenellus;* Lower Cambrian = St. John series, Newfoundland and Braintree, Mass., or *Paradoxides*.

LIST OF BOOKS AND PAPERS CONTAINING THE HISTORIC CLASSIFICATION AND THE ORDER OF DISCOVERIES.

BARRANDE (JOACHIM).

1846. Notice préliminaire sur le Système Silurien et les Tribolites de Bohême. 8vo, Leipzig. Primordial fauna.

—— Nouveaux Tribolites; supplément à la Notice préliminaire sur le Système Silurien et les Tribolites de Bohême. 8vo, Prague.

1851. Sur le terrain silurien du centre de la Bohême (*Bulletin Soc. géol. de France*, 2e série, tome VIII, p. 150), Paris.

—— Sur le Silurien de l'Angleterre (*Bulletin Soc. géol. de France*, 2e. série, tome VIII, p. 207).

1852. Système Silurien du centre de la Bohême (Vol. I, text and plates Tribolites). 4to, Prague.

1856. Parallèle entre les dépôts Siluriens de Bohême et de Scandinavie 4to, Prague.

1857. Extension de la faune Primordiale de Bohême (*Bulletin Soc. géol. de France*, 2e série, tome XIV, p. 439), Paris.

1859. Etat actuel des connoissances acquises sur la faune Primordiale (*Bulletin Soc. géol. de France*, 2e série, tome XVI, p. 516), Paris.

1860. Sur l'existence de la faune Primordiale dans la chaine cantabrique (*Bulletin Soc. géol. de France*, 2e série, tome XVII, p. 516), Paris. In collaboration with Casiano de Prado and de Verneuil, at pp. 545–546, Barrande describes the *Paradoxides Harlani* of Braintree.

—— On the Primordial fauna and the Taconic system, with additional notes by Jules Marcou (*Proceed. Boston Soc. Nat. Hist.*, Vol. VII, p. 369), Boston.

1861. Documents anciens et nouveaux sur la faune Primordiale et le système Taconique en Amérique (*Bulletin Soc. géol. de France*, 2e série, tome XVIII, p. 203), Paris. The most important memoir on the question of priority and the palaeontology.

1862. Assentiment du Professeur James Hall, et autres documents nouveaux, au sujet de la faune Primordiale en Amérique (*Bulletin Soc. géol. de France*, 2e série, tome XIX, p. 721), Paris.

1872. Système Silurien du centre de la Bohême (Supplément au Vol. I, Tribolites, etc.), 4to, Prague.

1880. Du maintien de la nomenclature établie par M. Murchison (*Comptes rendus sténographiques du Congrès international de géologie*, tenu à Paris du 29 au 31 août et du 2 au 4 septembre, 1878, p. 101). 8vo, Paris.

EMMONS (EBENEZER).

1838. Report of E. Emmons, Geologist of the Second Geological District of the State of New York, pp. 185, etc. Documents of the

State of New York, No. 200, in assembly, February 20. 8vo, Albany. (*Sandstone of Potsdam*, p. 214). In "Second Annual Report of the Geological Survey."

1842. Geology of New York, Part II, comprising the survey of the second geological district. 4to, Albany. The *Taconic System* constitutes Chapters VII, VIII and IX, pp. 135–164. No fossils.

1844. The Taconic System, based on observations in New York, Massachusetts, Maine, Vermont and Rhode Island. 4to, Albany. Fossils found and described.

1846. Agriculture of New York, Vol. I. The *Taconic System*, Chapter V, with an appendix, pp. 45–109 and 112. 4to, Albany.

1855. American Geology, Vol. I, Part II, pp. 1–122. 8vo, Albany.

1859–60. Manual of Geology, first edition in 1859 and a second edition in 1860. 8vo, New York.

LAPWORTH (CHARLES).

1879. On the Tripartite Classification of the Lower Palaeozoic Rocks (*Geological Magazine*, new series), Decade II, Vol. VI, January.

MARCOU (JULES).

1860. On the Primordial fauna and the Taconic system by Joachim Barrande. With additional notes by Jules Marcou (*Proceed. Boston Soc. Nat. Hist.* Vol. VII, p. 369, October) Boston. In it the Potsdam sandstone is placed for the first time as the last term of the Taconic, instead of being the first term of the Lower Silurian or Champlain.

1861. Sur les roches fossilifères les plus anciennes de l'Amérique du Nord. In two letters to Elie de Beaumont, September, 1861 (*Comptes rendus de l'Academie des Sciences de France*, tome LIII, pp. 803 and 915, Novembre, 1861). Paris.

—— The Taconic and Lower Silurian rocks of Vermont and Canada (*Proceed. Boston Soc. Nat. Hist.*, Vol. VIII, p. 239, November, 1861), Boston, one hundred separate copies printed, with a title-page dated 1862.

1862. Liste additionelle des fossiles du terrain taconique de l'Amérique du Nord (*Bulletin Soc. Geol. du France*, 2e série, tome XIX, p. 744) Paris.

—— Letter to M. Joachim Barrande on the Taconic rocks of Vermont and Canada, August, 1862, Cambridge, Mass. For the first time "lenticular masses of limestone" inclosed in the Taconic slates are recorded.

1864. Notice sur les gisements des lentilles trilobitifères taconiques de la Pointe-Lévis au Canada. (*Bulletin Soc. géol. de France*, 2e série, tome XXI, p. 236), Paris.

1881. Sur les colonies dans les roches taconiques des bords du lac Champlain (*Bulletin Soc. géol. de France*, 3e série, tome IX, p. 18, Novembre, 1880), Paris.

1885. The Taconic system and its position in stratigraphic geology. (*Proceed. American Acad. Arts and Sciences*, new series, vol. XII, p. 174), Cambridge, Mass. In it is found the correspondence of Emmons, Barrande and Billings.

MARR (JOHN E.).

1883. The classification of the Cambrian and Silurian rocks. Being the Sedgwick prize essay for the year 1882. 8vo, Cambridge.

MURCHISON (RODERICK I.).

1836. On the Silurian and Cambrian systems, exhibiting the order in which the older sedimentary strata succeed one another in England and Wales, by A. Sedgwick and R. I. Murchison (*Report British Association for* 1835, p. 59).

1839. The Silurian system, 4to, London.

1854. Siluria, 8vo, London.

1859. Siluria, Third edition, 8vo, London.

1867. Siluria. Fourth edition, 8vo, London.

SEDGWICK (ADAM).

1836. Ordre de superposition et caractères géologiques des roches de Cumberland et du pays de Galles; extrait d'une lettre à Elie de Beaumont (*Bulletin Soc. géol. de France*, 1e série, tome VII, p. 152), Paris.

1838. Synopsis of the English series of stratified rocks inferior to the Old Red Sandstone, with an attempt to determine the successive natural groups and formations. (*Proceedings Geological Society of London*, Vol. II, No. 58, p. 675, London).

1851–55. A synopsis of the classification of the British Palaeozoic rocks. With a systematic description of the British Palaeozoic fossils in the Geological Museum of the University of Cambridge by Frederick McCoy, 4to, Cambridge, 1852–55.

1873. A catalogue of the collection of Cambrian and Silurian fossils contained in the Geological Museum of the University of Cambridge, by J. W. Salter, with a preface by Adam Sedgwick. 4to, Cambridge. The lower and middle Cambrian contain the Primordial fauna, collected and described since 1863: twenty years after the discovery of the fossils of the Taconic system of Dr. Emmons, seventeen years after the description of the Primordial fauna of Bohemia by Barrande, and twelve years after Barrande's announcement of the existence of the Primordial fauna in Wales.

WALCOTT (CHARLES D.).

1884. On the Cambrian faunas of North America. Preliminary studies (*Bulletin United States Geological Survey*, No. 10) 8vo, Washington.

1886. Second contribution to the studies on the Cambrian faunas in North America. (*Bulletin United States Geological Survey*, No. 30.) 8vo, Washington.

General Meeting, March 16, 1887.

The President, Mr. S. H. Scudder, in the chair.

Prof. Wm. M. Davis read a paper on geographic classification in which he explained the difficulties of the present method of describing the form of the surface of a country, and the advantages of a classification of geographic forms based on their development.

Prof. A. Hyatt compared this system of classification to one long ago proposed by him for animals.

Prof. F. W. Putnam showed a collection of perforated stones from California, including some unfinished, showing how they were made. Some were made from water-worn pebbles and others from rough pieces shaped by pounding the surface with other stones. The perforations were made by picking with a pointed stone and were afterward enlarged and smoothed by rubbing. Four of these stones were shown with the handles still attached. The handles are sticks passing through the perforation and held in place by asphaltum. These mounted specimens were found in a cave in California, and are the only ones ever found in this country attached to handles and give conclusive evidence that at least some of the California stones were club-heads. Similar perforated stones have been found in other countries and were used for various purposes. It is known that in southern Africa they are used as weights to digging-sticks.

Dr. S. Kneeland read an account by Le Matayer de Guichainville of the caterpillars so destructive to the foliage on the trees in the squares of New York.

Section of Entomology, March 23, 1887.

The President, Mr. S. H. Scudder, in the chair.

Mr. Scudder called attention to an interesting paper printed in the Geological Magazine, in which Dr. Woodward describes several new forms of British carboniferous cockroaches. One of them is of particular interest as closely allied to Blattina insignis of Goldenberg, original drawings of which were shown to the Section; it is placed by Woodward with it in a distinct genus Leptoblattina, remarkable for the slenderness of the abdomen and the depauperated wings combined with a large prothorax. The two species are readily separable by the form of the prothorax, which is much broader in the English than in the German species. That in each case the animal should have been so completely preserved, and that no wings at all similar to them should have been separately found (unless possibly Gerablattina germari is a case in point), when almost all carboniferous cockroaches are known by their wings alone, is not a little remarkable. There is no doubt that they belong together and should form a distinct genus. The neuration of the two agrees better than was supposed by Woodward. Another species is referred to Lithomylacris and would be interesting as the first instance of the occurrence of the Mylacridae in the Old World if it were correct, but the structure of the mediastinal branches shows without the least doubt that it belongs to the Blattinariae. It is, in fact, apparently a Hermatoblattina, allied to H. lebachensis, but much smaller.

Mr. Scudder also referred to the glands and extensile organs found on the dorsal surface of the larvae of certain blue butterflies, and which had been shown to excrete a fluid substance attractive to ants. This peculiarity was first observed twenty years ago by Guenée in a European species but had latterly been more fully set forth with illustrative figures by Mr. W. H. Edwards in the case of one of our own species, Cyaniris pseudargiolus. Mr. Edwards showed that there were two sets of organs, a transverse slit on the seventh abdominal segment, through which a minute vesicle could be extruded, and which is the point of attraction to the ants; and a pair of extensile organs near the spiracles of the succeeding segment, furnished with an apical crown of spicules, the use of which is problematical.

A recent examination of all the larvae of Lycaeninae obtainable shows that the transverse slit of the seventh abdominal segment probably exists in all Lycaenidi as well as in some Theclidi, as it occurs among the blues in our own pseudargiolus and comyntas and in the European argiolus, icarus, minima, iolas, egon, admetus and corydon; and also in Thestor ballus and the European Theclidi, ilicis and roboris. No such gland occurs in our Thecla strigosa, nor in the following European Theclidi: quercus, rubi, spini and betulae; nor is it found in Heodes phloeas or hypophlaeas nor in Feniseca tarquinius.

The lateral extensile organs of the eighth abdominal segment are less common. Among the Lycenidi they occur in our comyntas and pseudargiolus and in the European argiolus, aegon, admetus and corydon, but are absent from minima and iolas, and apparently from icarus. They are found also in Thestor ballus, but in none of the Theclidi or Chrysophanidi mentioned above.

The species in which they were both observed by Guenée was baetica, adding another to the list. Goossens also found them in the European argiolus and expressed the opinion that they will be found in all the other blue butterflies.

General Meeting, April 6, 1887.

The President, Mr. S. H. Scudder, in the chair.

Dr. E. G. Gardiner discussed the development and homologies of hoofs, claws and nails, describing his observations on the hoof of the pig, horse and other animals, compared with the claws of the carnivora and nails of the ape and man.

Mr. Scudder read a paper on fossil butterflies showing the relationships of the known species, and comparing the Old World with the New World forms.

General Meeting, April 20, 1887.

The President, Mr. S. H. Scudder, in the chair.

The following paper was read :—

NOTE ON THE EPIDERMAL SYSTEM OF BIRDS.

BY J. AMORY JEFFRIES, M.D.

Some time ago Dr. E. G. Gardiner[1] attacked parts of my article, on the "Epidermal system of Birds," read before this society in 1883; since then accident has prevented my replying.

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[1] Beiträge zur Kenntniss des Epitrichium und der Bildung des Vogelschnabels (Arch. Mikr. Anat. XXIV, 289.)

I held that there was an outside single layer of cells distinct from those below; my reasons being the early formation of such a superficial layer in the chick and its endurance till near the end of incubation, the presence of the same structure in the other vertebrate groups, its renewal with each moult in reptiles and apparently in the pin feathers of birds.

To this Dr. Gardiner takes exception on grounds which it is hard to summarize from his article.

First, he considers there cannot be enough growth in this layer to cover the chick, that cell-division cannot be sufficient, and that the increase in size is surely not enough. In proof of this he states that he has measured camera drawings of the epitrichium given by me, of the five and twenty days' chick and finds the cells about twice as large in the latter, as in the former.

Second, that gaps occur in this outer layer which are stopped by cells from below.

Third, that the layer does not exist on the body proper.

It will be noted that objections one and two presuppose the existence of an outside layer, otherwise he could not talk about the cells below becoming incorporated in it. But the existence of such a layer is put beyond doubt by the specimens on the table. As to cell-division he does not deny it, and it undoubtedly does occur while the amniotic fluid maintains its original constitution and affords a good food supply. This division is shown by the double nuclei found by all. In regard to the size of the cells, Dr. Gardiner has made some serious mistakes due perhaps to haste. I do not give a figure of the epitrichium of a twenty days' chick, so he could not measure it as he maintains. The figure of the fourteen days' chick shows an increase of about two (really two and a half) in linear measure making six and a fraction times as much surface area. I hold that the cell multiplication in the early stages and the cell-flattening with a resultant six-fold surface, suffice to cover the chick. As has been shown, Dr. Gardiner's objections are based on errors.

The second objection that gaps occur which are filled up from cells below is supported by no evidence. He does not describe how the cells below change their form and structure under reaction, nor does he give a figure of such cells in process of transition. Indeed, he nowhere gives a figure showing the epitrichium in a recognizable form. Figure 18 is marked epitrichium but looks like the so-called granular layer below. This figure is not explained, no description being given of the reagents used in preparing the specimen, of the lenses used in examining it, from what part it was taken, nor even if it be a section or a surface view. So it seems unwise to accept the statement blindly. How fusiform, horny cells can turn into a flat polygonal layer is difficult to explain, yet such is the difference in much of the skin.

I regret that Dr. Gardiner has not found an outer layer on the body, but I cannot accept that as proof against my finding it.

Dr. Gardiner seems disposed to doubt the accuracy of my description of a fold at the base of the bill. This specimen shows it as you can satisfy yourselves.

On page 26 we read "It seems as if Dr. Jeffries had misread, since he says Kerbert has given no description of the epitrichium during the last days of incubation; on the contrary, Kerbert has remarked that it is lost before the shedding of the granular layer." I wrote (page 223), "Kerbert does not describe the epitrichial layer but says it becomes lost."

In closing I would call your attention to the paper by Klee,[1] which completely verifies my observations, though worked out in ignorance of my article.

ANNUAL MEETING, MAY 4, 1887.

The President, Mr. S. H. Scudder, in the chair.

The following reports were presented:

REPORT ON THE MUSEUM. BY ALPHEUS HYATT, CURATOR.

THE first of the Guides to the Society's Museum was issued early in the year, but owing to unavoidable delays it was not placed on sale until late in the autumn. It is an experiment of considerable importance in Museology. It is not in any sense a mere catalogue, as are most books of the same title, but an instructive though much abbreviated manual of mineralogy, illustrated by fine collections, which have been prepared for this purpose with great labor and considerable expense.

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[1] Bau und Entwickelung der Feder, Zeitschr. f. Naturwiss. 1886, 110-156.

The publication of the Guide had to be borne by the museum appropriation, and consequently no money was left for other purposes. The cases intended for the exhibition of Dynamical Geology and Biology could not, therefore, be erected in the vestibule nor these collections completed. Professor Crosby and the Curator have been occupied more or less with the plans and in writing the guide for these collections, but these are as yet only in the first stages of preparation. The specimens and models now on exhibition in the vestibule were arranged by Professor Crosby; and, though not yet complete, are sufficient to prove the utility of the proposed dynamical collections. They exhibit the action of forces in the formation of the crust of the earth and its parts in a way that cannot fail to be very instructive to an intelligent visitor, and help every one to a better comprehension of the meaning of the exhibits in the other departments of the Museum.

Unusually heavy burdens were thrown on the funds of the Society by the necessity of renewing the boilers for heating the building. This expense was, however, successfully met, though it was unexpected, and occurred after the alterations in the basement, for the purpose of making a new class room, had gone so far that they could not be postponed.

The policy of the Society has always been to give up any of its departments provided other institutions would accept and carry them on. This policy has governed our late action with reference to the summer laboratory at Annisquam. We conducted this department with the aid of the Woman's Education Association, for six consecutive summers. It has been entirely successful, and the policy pursued has been frequently spoken of in former reports. The Woman's Education Association makes it a rule never to carry on any of their undertakings after they have passed through the experimental stage of existence. Both the Society and the Association have therefore felt, after six years of successful working, that the laboratory had reached a stage of advancement when it could claim and perhaps receive sufficient support from the patrons of science and learning to be placed upon an independent and permanent foundation. The time also was considered propitious, since last summer had been one of the very best and most productive in the history of the laboratory.

The Woman's Education Association called a meeting composed largely of representative teachers of biology and the fate of the laboratory was surrendered to their deliberations. They decided that an effort should be made to establish a marine biological laboratory, and at least $15,000 should be raised to carry it on for five years. They appointed a body of Trustees and proceeded to solicit subscriptions and are now engaged in this work.

Mineralogy.

This collection is now finished, and it is to be hoped it will not, at least for a period of some years, require any important changes. One hundred and nineteen copies of Professor Crosby's Guide have been sold at twenty-five cents each, the lowest price which the publication committee considered advisable. The book may perhaps in course of time pay its expenses, but even this is doubtful. As time rolls on, the necessary changes, which will have to be made in the collections in order to keep up with the progress of science, will probably entirely swallow up any profits made from sales.

The Guide and the collections are now used by Professor Crosby in the instruction of his class at the Institute of Technology, and it will eventually come into use with many teachers of the Boston public schools and others interested in this subject.

The principal accessions have been as follows: fine crystals of smoky quartz and chalcopyrite from Pennsylvania, acquired by purchase; a large specimen of rock salt from Turk's Island, and others from Cheshire, England; opalized wood from Montana, by exchange with the National Museum; numerous minerals from western Massachusetts, for the New England collection, chiefly obtained by exchange with Prof. B. K. Emerson of Amherst.

Geology.

Professor Crosby has been engaged chiefly in writing the manuscript for the Guide to the collections of Dynamical Geology, in the construction of models and in preparing and collecting materials and illustrations for exhibition in these collections. Some of these have been placed upon the table and their great value will be recognized by the members present. I desire especially to draw attention to the examples of denudation and of contorted rocks. The minute caverns and pillars of one specimen exhibit the action of the sea as perfectly as any series of caverns of large size cut out of huge cliffs on the seashore, and the specimens of folded rocks are as good examples of the pliability of strata under pressure as are the Alps or the Appalachians. It will be seen, also, that it is much easier to comprehend the more gigantic effects of natural forces when interpreted by the sight of these liliputian but strictly parallel examples.

Botany.

The generosity of Mr. John Cummings, in continuing his support of this department, cannot be too highly appreciated. Next to the birds and insects, it would have required more attention than any other and would have been a heavy burden upon the Society's funds, if not taken in charge by this gentleman. We have not only been relieved of the burden of its support, but have had the advantage of the aid of Mr. Cummings' assistant in other departments during a considerable proportion of the past thirteen years.

The work of revising the herbarium has been carried on by Miss Carter, under Mr. Cummings' direction, and has been completed with the exception of the Gramineae and Cyperaceae.

The endogens, exclusive of these two orders, contain 1,512 specimens, representing 916 species and 280 genera. This is a gain of 228 species and varieties, which have been rescued from the old collection of so-called duplicates laid aside by a former curator of botany. Considerable work has been done in determining unnamed specimens of Gramineae and Cyperaceae, for which we are under obligation to Professor Scribner of U. S. Agricultural Department and Miss S. Minns of Boston. The work of completing our New England Herbarium has been carried out as far as can be done with the materials in our possession. Mr. T. T. Bouvé has also added to this collection one hundred fine specimens mostly from Hingham.

Considerable work in the poisoning of the dried plants has been done. Twenty specimens of rare species of lichens have been received from Prof. Johann Mueller of Geneva, and the plates of Victoria Regia for use in the exhibition collection from Mr. James Sharp of Dorchester. The number of persons applying for permission to use this department continues to increase, and indicates that the interest in the study of Botany is increasing.

Comparative Anatomy.

About twenty-five specimens and preparations, procured and made by Mr. Henshaw, have been added to this department, as well as a skeleton of Cynocephalus porcarius, prepared and presented by Mr. Holmes Hinkley.

Sponges.

Miss Martin has made a large and valuable series of microscopical preparations of the skeletons of the Keratosa for the purpose of deciding of what value the size of the threads may be in the determination of species, a matter of importance to all special students of this group in which the species are extremely difficult to define. The study of the Keratosa of Bermuda was finished early in the year and the collections have been returned to the National Museum.

Mollusca.

Good progress has been made by Mr. Henshaw, assisted by Miss Martin, in working over the miscellaneous materials stored in this department. Over 1700 lots of univalves have been sorted out, partially identified and arranged. The enlargement of the exhibition collection has been completed so far as the Gasteropoda, Pteropoda and Cephalopoda are concerned, and it now contains 13,804 specimens, and 209 models and preparations, representing 3,755 species. The entire systematic collection of Gasteropoda, Pteropoda and Cephalopoda, now contains 34,681 specimens representing 5,094 species. The revision of the New England collection of Mollusca has been finished by Mr. Henshaw. It contains 1,500 specimens, representing 300 species. Specimens have been received as donations, or in exchange, from Messrs. C. B. Fuller, John Ritchie, Jr., E. W. Roper, and Dr. A. Shurtleff.

Crustacea.

Mr. J. S. Kingsley has helped Mr. Henshaw in the work of revising the valuable collection of Crustacea he presented to the society in 1881 and this work is now finished. It contains 2,900 specimens representing 400 species.

Insects.

The additions to this department have been unusually large. First to be mentioned is the general collection of Mr. Edward Burgess, announced in the last report. This consists of about 6,000 specimens and is especially useful for the New England material and for a fine lot of European micro-lepidoptera.

We have obtained through exchange a collection of about 1,000 Diptera, chiefly from New England, with some interesting forms from Texas. This collection, when worked up, will be very useful, as we are poorer in New England Diptera than in any other order of insects. We have received by exchange fifty specimens of Hymenoptera from San Domingo, forty specimens of Brazilian Lepidoptera and a small lot (about seventy-five specimens) of European Hemiptera. All of these were selected to fill gaps in our series.

Dr. H. A. Hagen and Mr. S. H. Scudder have, as usual, presented specimens to this department.

The reception of the Burgess collection made it necessary to revise our New England collection. This has been done (though the identification of the Hemiptera, Diptera and Hymenoptera is incomplete) and the following summary shows the extent of our series :

	Species.	Specimens.
Neuroptera	90	150
Orthoptera	74	175
Hemiptera	190	392
Coleoptera	2075	5404
Diptera	130	315
Lepidoptera	684	1673
Hymemoptera	394	796
	3637	8905

The exhibited collections of generic types of Coleoptera and Lepidoptera have been revised and, owing to insufficient space for the display of the whole series, the genera from New England, which could be spared better than those from other parts of the world, have been taken out.

This generic collection contains:

Lepidoptera	235	genera
Coleoptera	617	"

The New England collection contains:

Lepidoptera	357	genera
Coleoptera	697	"

Birds.

A number of the New England Birds have been remounted and about a dozen species have been added to the collection.

We have received, in exchange, from Prof. Alfred Newton of Cambridge, England, a specimen of the rare Jamaica petrel (Oestrelata jamaicensis) from St. Andrews, Jamaica.

Paleontology.

The activity in this department has been greater than in previous years.

The Newfoundland collection has been at length unpacked and it now lies spread out upon temporary tables in one of the basement rooms. It is in good condition and is a large and valuable addition to the Society's treasures. Mr. Parmelee and Mr. Newell, students of the Institute of Technology, have done considerable work upon this collection in making a preliminary arrangement and in sorting and labelling the specimens. These gentlemen have assisted the Society while at the same time doing work in the direct line of their own studies. They have also sorted and labelled the collection gathered last summer by the Curator and his party near St. Armands, which are more particularly mentioned farther on in this report.

A series of the beautiful fossil leaves found in the Dakota group of Ellsworth Co., Kansas, have been obtained by exchange from Prof. F. H. Snow of the University of Kansas. Many of these are new species, and all are types, either published or soon to be published by Professor Lesquereux. We have also acquired by purchase a series of fine specimens of the fossil corals from the limestones at the Falls of the Ohio. Both of these lots have been catalogued, mounted, and placed on exhibition by Mr. Henshaw. The Society is indebted to Miss Elizabeth D. Boardman who has done considerable work upon the Curator's collection of Steinheim shells, and when this is finished he will be able to present to the Society a complete series of these valuable fossils.

We have received a very acceptable gift from Prof. O. C. Marsh, in the cast of the femur of Atlantosaurus, and we are indebted to Sir William Dawson for the donation of several specimens of fossil plants.

The collections not mentioned remain substantially unchanged since the last report.

Teachers' School of Science.

The liberal action of the trustee of the Lowell fund, in defraying the expenses of the lessons and in granting the use of Huntington Hall, has enabled the Society to continue to extend the benefit of the instruction in this school to teachers of neighboring towns as well as to those living in Boston. The agents, who acted in these towns and villages in previous years, continued their kind offices, distributing and receiving applications and also tickets according to the plan of which details were given in the report of 1883. The superintendent of public schools in this city has also kindly assisted us by attending to similar technical details in Boston.

Two courses were given in Huntington Hall under the auspices of Mr. Augustus Lowell. The first consisted of five lessons on

Problems in Physical Geography. Geographic classification was treated of in two lessons and the laws of the evolution of the principal topographical types occupied the remainder of the course. Professor Davis gave the class the benefit of the results of his investigations, which are original contributions of importance to the progress of physical geography. The effectiveness of the graphic modes of illustration, by means of diagrams and models, demands special notice, especially the lesson upon the glacial period and the effects of the great glacier upon the area of the great lakes. This was shown by means of a relief model whose surface was composed of an ingenious arrangement of overlying and differently painted surfaces. By removing these in succession, the lecturer traced the whole history of changes following upon the recession of the continental glacier, and its effects upon the surface waters, especially upon the outlines of the Great Lakes and the changes in their outlets. The impression made upon the audience by this mode of presentation satisfied us that a great improvement in the modes of instruction in physical geography could be introduced by following out this method. The average attendance was one hundred and forty-three.

The second course consisted of ten lessons on American Archaeology by Prof. F. W. Putnam of Harvard University. The topics selected covered the whole range of the remains of prehistoric man and his life on this continent, so far as these subjects could be presented in ten lessons. The original methods of research elaborated by Professor Putnam, which have made his name the first in his chosen department of archaeological work, rendered this course remarkably interesting and instructive. Specimens were studied and given away in sufficient numbers to illustrate the modes of making stone implements and some of the different kinds of pottery. The costliness and rarity of most of the objects, however, naturally prevented any further extension of our usual mode of practical instruction.

Professor Putnam also invited the teachers to make a visit to the Museum, of which he is director at Cambridge, after the close of the course, and there gave them an opportunity to inspect the larger objects, which it had not been possible to bring into the city. His audience became so much interested in the famous serpent mound in Ohio, now threatened with destruction, that a voluntary subscription was raised and given by a committee of teachers to assist in purchasing and preserving this ancient monument. The average attendance was two hundred and three.

Number of applications received: Physical Geography, 613; American Archæology, 844.

Number of tickets distributed.		To teachers.	To others.
Physical geography,	752	574	178
American archæology,	980	780	200
	1732	1354	378

GRADE OF TEACHERS.

Boston Public Schools.

	Tickets distributed to	
	Phys. Geog.	Arch.
Masters	27	31
Sub-masters	24	23
Assistants	385	542

Out-of-town Schools.

	Tickets distributed to	
	Phys. Geog.	Arch.
Masters and Principals	27	33
Sub-masters	3	1
Assistants	108	150

LIST BY TOWNS.

	Phys. Geog.	Amer. Arch.
Boston	436	596
Brockton	3	6
Bridgewater	2	0
Brookline	10	18
Cambridge	30	55
Chelsea	9	7
Cohasset	2	0
Concord	0	3
Everett	0	1
Glenwood	1	0
Greenwood	1	0
Hingham	2	5
Hyde Park	16	14
Malden	3	6
Mattapan	2	1
Medford	10	11
Melrose	6	6
Newton	22	22
Quincy	2	0
Randolph	1	1
Roslindale	3	2
Salem	3	4
Somerville	5	12
Stoneham	1	4
Woburn	4	4
Waltham	0	1
Wellington	0	1
Total	574	780
Complimentary	139	139
Miscellaneous	39	61
	752	980

Two additional subscription courses were given at the earnest request of teachers. The late Miss Lucretia Crocker, whose untimely death took away from the school one of its strongest supporters and most active co-workers, obtained the funds for the first. This was in continuation of the course given last year by Prof. W. O. Crosby, and was particularly addressed to the needs of the grammar schools. Twelve lessons were given by Mrs. Richards, for which one hundred and twenty-seven tickets were distributed to teachers, all but fifteen of whom were engaged in the grammar schools of Boston. Eighty sets of specimens illustrating this course were distributed, amounting to 2240 minerals. The average of attendance was eighty, a very large proportion for a free course, especially considering the stormy weather. Professor Crosby followed this with twelve lessons on Determinative Mineralogy, giving a course of great practical importance for those engaged in trying to teach mineralogy. This course was sustained by fees paid by the teachers themselves. The expense was five dollars and fifty cents for each person. The average attendance was very large, nearly all of the class of forty-six being present at every lesson.

Winter Laboratory.

The lecture room in the basement having proved too small for the double purpose of accommodating students, and the collections for teaching them, it was thought advisable to alter and refit the quarters formerly occupied by the janitor. The partitions dividing the large room in the southwest corner of the basement were removed and the room restored to its former dimensions. It was then sheathed up to a convenient height on the sides, painted, proper ventilators introduced and it was thus transformed into a very comfortable and commodious class room. The old room is still retained as a storage and work room, and this enables us to keep the class room free of incumbrances. The rooms have been occupied as usual by a class in Zoology and Paleontology from the Massachusetts Institute of Technology, and a class in Zoology from Boston University, both of these being under the charge of the Curator; also by a class in Botany and a class in Physiology, both from Boston University and both under the charge of Mr. B. H. Van Vleck. These rooms have also been used once by a special class from one of the public schools, and by special students.

Summer Laboratory.

This department, as in former years, has been carried on by means of donations received from the Woman's Education Association. These ladies contributed this year the full amount necessary for carrying on the laboratory, and also generously paid the assistant, Mr. Van Vleck, a salary of seventy-five dollars per month.

The success of the laboratory was this year far beyond that of the previous summer. It opened June 15 and was closed Sept. 20, having been conducted throughout the summer by Mr. Van Vleck. The total number of students was double that of last year, there being twenty-six in all. Thirteen of these were men and thirteen women. The average time of attendance was thirty-four days, an advance of five days upon the average of last year. The steady gains and success of this department are matters for congratulation, but the time had come for making an effort to found a distinct institution, one standing upon an independent foundation; and consequently, as stated in the prefatory remarks, it has passed out of our hands.

Expedition.

During the summer of 1886 a short excursion in search of fossils was made. The party consisted of the Curator accompanied by Mr. G. L. Parmelee, student of the Massachusetts Institute of Technology, Mr. Robert T. Jackson, student of Harvard University, Mr. Hildreth of Cambridge, and the son of the Curator. The time occupied on the ground was about three weeks altogether. Ten days only were given to the limestones near St. Armands and during the rest of the time the party visited Swanton, Isle La Motte, Chazy, and Au Sable Chasm. The collecting was very successful in the limestones at St. Armands, usually called the Phillipsburg limestones. A very remarkable and large Nautilus, two extremely large and one very perfect Piloceras, and over a dozen fine specimens of the very rare Lituites of that formation were obtained. The scientific results are not yet fully ready for publication, but it has become apparent that the Lituites are undoubtedly degraded forms of still more ancient genera of close coiled Nautiloids of which no trace has yet been discovered in the older rocks of Taconic age. This can be proved by the young of the Lituites, which give positive evidence of the former existence of faunas of greater antiquity than those which must have given birth to the Cephalopoda of the Phillipsburg limestones or their close allies the Trocholites and similar forms of the Chazy and Newton. A result of considerable interest from a stratigraphical point of view may also be stated. The species are the same in some cases as those lately found in the limestones at Fort Cassin, described by Whitfield in the Bulletin of the American Museum as probably synchronous with the Birds-eye limestones of New York. The kindness of Mr. Whitfield has enabled the Curator to make his comparisons with the original materials from Fort Cassin described by him.

REPORT ON THE SECRETARY AND LIBRARIAN BY EDWARD BURGESS, SECRETARY.

In the past year the Secretary finds in his department no important event to chronicle. The annual averages given below show the usual figures, and except in the case of membership are to that extent satisfactory.

Membership.

It seems desirable to call special attention to the need of increasing our membership for the losses in the roll from death and other causes much exceed the number of members added. During the past year we have lost four Associate Members by death, fifteen by resignation, and twelve have been dropped for non-payment of dues, a total of thirty-one, while only thirteen have been elected. The Corporate class is reduced three by death, one by resignation, and one by forfeiture. Two Life Members of long standing, Dr. Charles D. Homans and Mr. James A. Dupee, have died.

Isaac Lea, the veteran conchologist, elected an Honorary Member in Jan., 1837, died last December.

We have elected one Corporate and two Corresponding Members during the year.

The total resident membership is now three hundred and forty-two. There is certainly no reason why the Society should not number twice as many.

Meetings.

At the usual sixteen general meetings the average attendance has been twenty-seven, the largest seventy-six and the smallest seven. The regular attendance has been about the same as during the last five years. It seems to me that the interest and value of the meetings would be enhanced by holding only one instead of two monthly meetings, for it is now very difficult to provide communications.

Twenty-eight communications have been made during the year.

Library.

The additions to the library number 2268, as follows:

	8vo.	4to.	Fol.	Total.
Volumes,	212	62	3	277
Parts,	1,324	255	42	1,621
Pamphlets,	326	37	4	367
Maps,			3	3
				2,268

A large number of works from the library of the late Dr. Samuel Cabot have been presented by his heirs. The Secretary has also given a number of books.

We have subscribed to the Archives Italiennes de Biologie, Archives Slaves de Biologie, the Zoölogische Jährbucher, and the Monographs of the Flora and Fauna of the Gulf of Naples; and have arranged for several new exchanges.

Nine hundred and twenty-nine books were borrowed from the library by ninety-four persons.

One hundred and seventy-five books have been bound.

Publications.

Three memoirs have been issued: The life-history of the Hydro-medusae, by Dr. W. K. Brooks, with four plates; The supposed Myriapodan genus Trichiulus, the oldest-known insect larva, Mormolucoides articulatus, from the Connecticut river rocks, and a Review of Mesozoic Cockroaches, by Mr. S. H. Scudder, with three plates; and the Significance of Bone Structure, by Dr. Thomas Dwight, with three plates. The latter memoir forms No. 1 of Vol. IV. One part of the Proceedings, Part II, Vol. XXIII, and three signatures of the next part have been issued. The Proceedings are now in type to date.

Walker Prizes.

Only one essay on the subject announced for this year's Walker Prize—Original Investigations in Lithology—has been presented, and the committee will duly report upon it this evening.

Annual Statement of Receipts and Expenditures, Boston Society of Natural History, May 4, 1887.

May 1, 1886, to May 1, 1887. RECEIPTS.

Admission Fees	$ 55.00	
Annual Assessments	1,045.00	
Dividends and Income from General Fund	3,953.00	
"Walker Fund." Income	2,325.13	
"Walker Prize Fund." "	295.00	
"Courtis" Fund. "	454.00	
"Bulfinch St. Estate" Fund. "	1,736.00	
"S. P. Pratt" Fund. "	556.00	
"Huntington F. Wolcott" Fund. Income	414.00	
Entomological Fund. Income	20.00	
Laboratory, from Boston University, etc.	2,525.00	
Proceeds sale ten shares Boston and Albany R. R. Stock from accrued Income of Walker Fund for special purposes	1,997.50	
Balance	148.86	
		$15,524.49

May 1, 1886 to May 1, 1887. EXPENSES.

Museum		$783.53	
Library		782.06	
Publications and Printing	1160.43		
Less received on this Account	368.02	792.41	
Salaries and Wages		7,205.00	
Repairs of Building		1,962.37	
Fuel		216.11	
Gas		58.80	
General Expense		1,099.41	
Laboratory		2,564.80	
Walker Prize paid to Douglas H. Campbell		60.00	
			$15,524.49

BOSTON, MAY 4, 1887.

CHARLES W. SCUDDER,
Treasurer.

The following report of the auditing committee was read:

We have examined the foregoing accounts of Charles W. Scudder, Treasurer, for the current year and find them correct with proper vouchers. We have also seen and verified the evidences of the property held by the Society and the Trustees of the Walker Fund.

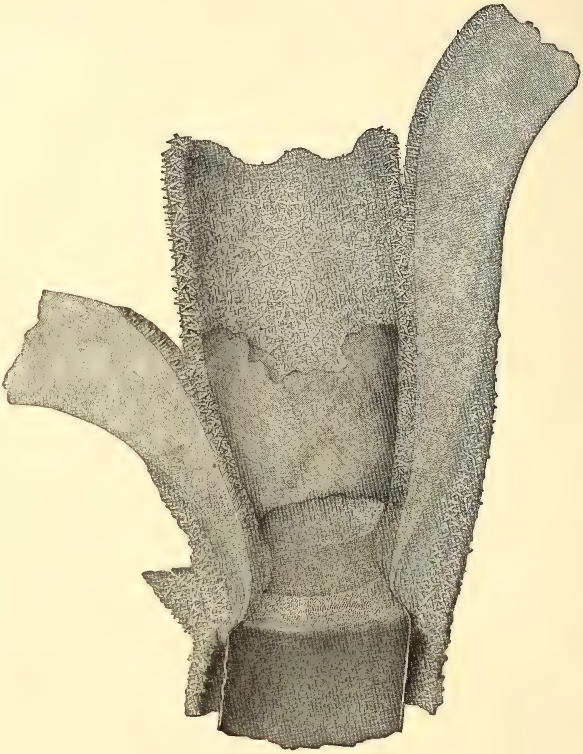
[Signed] Richard C. Greenleaf.
John Cummings.

Boston, *May* 3, 1887.

The Committee on Walker Prizes reported that only one paper had been received, that the author had not complied with the conditions governing the presentation of papers for the prize, and that the paper was not worthy of consideration.

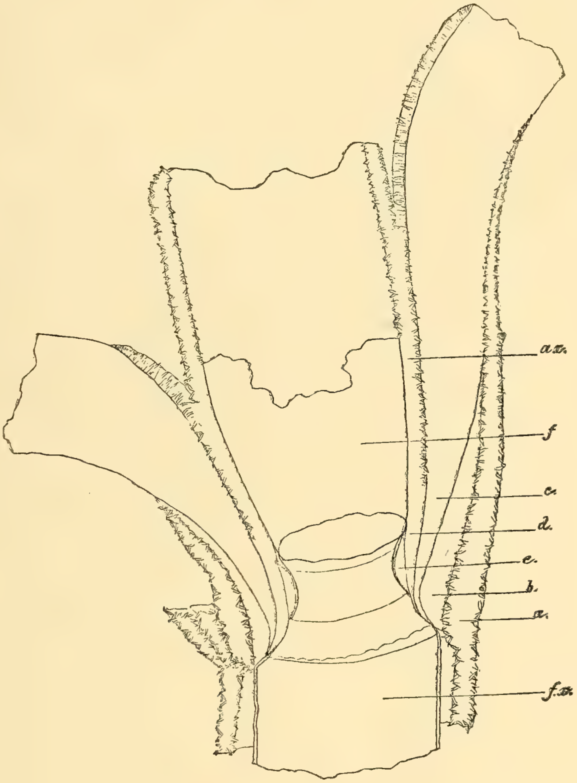
The Society then proceeded to ballot for officers. Messrs. E. G. Gardiner and R. Hayward were appointed a committee to collect and count the ballots.

The committee announced that the following named members of the society were elected to the respective offices for the ensuing year:—



F. W. COBB, DEL.

BROOKS, STRUCTURE OF THE SIPHON AND FUNNEL
OF NAUTILUS POMPILIUS.



F. W. COBB, DEL.

BROOKS, STRUCTURE OF THE SIPHON AND FUNNEL OF NAUTILUS POMPILIUS.

OFFICERS FOR 1887–88.

PRESIDENT,

FREDERICK W. PUTNAM.

VICE-PRESIDENTS,

JOHN CUMMINGS, GEORGE L. GOODALE.

CURATOR,

ALPHEUS HYATT.

HONORARY SECRETARY,

SAMUEL L. ABBOT.

SECRETARY,

EDWARD BURGESS.

TREASURER,

CHARLES W. SCUDDER.

LIBRARIAN,

EDWARD BURGESS.

COUNCILLORS,

Henry P. Bowditch,
William M. Davis,
George Dimmock,
James H. Emerton,
William G. Farlow,
Charles L. Flint,
Edward G. Gardiner,
Henry W. Haynes,
B. Joy Jeffries,
Augustus Lowell,
Edward L. Mark,
Charles S. Minot,
Edward S. Morse,
William H. Niles,
Ellen H. Richards,
William T. Sedgwick,
Nathaniel S. Shaler,
Charles J. Sprague,
Samuel Wells,
William F. Whitney.

MEMBERS OF THE COUNCIL, EX-OFFICIO,

Ex-President, Thomas T. Bouvé,
Ex-President, Samuel H. Scudder,
Ex-Vice President, Richard C. Greenleaf,
Ex-Vice President, D. Humphreys Storer.

Mr. Scudder, on withdrawing from the presidential chair, thanked the Society for its uniform courtesy and support during the seven years in which he had directed its deliberations. He had been a member of the society now for a generation, had even held some office for half his life-time; and in retiring from his position had no wish nor intention of withdrawing from the active service of the Society, whose best interests were and ever would be his own.

Professor Putnam then took the chair. In a few well chosen words he thanked the Society for the honor of his election, while he could but regret that Mr. Scudder had persisted in his determination to decline a reëlection to the position he had so worthily filled, and in which he had done so much to promote the interests of the Society. He then asked for the support of the members in carrying on the Society's work.

A communication from the Council recommending the passage of the following resolution was read:

Whereas an effort is being made to establish a marine biological station upon the New England coast, and whereas it is the opinion of this Society that such a station is urgently needed and will be of great benefit to science and education,

Resolved: That the Boston Society of Natural History expresses a cordial approval of the attempt to start the proposed station and directs the Council of the Society to coöperate in the foundation and maintenance of the station in such ways as it shall deem most advantageous to science and suitable for the Society.

The resolution was unanimously adopted.

The following letter was read:

71 *Chester Square*, *May* 4, 1887.

Edward Burgess, Esq.

Secretary Boston Society of Natural History:

Dear Sir: I have received the notice of the Annual Meeting of the Boston Society of Natural History, and as the state of my health will prevent me from being present I desire to say to the members that my absence from this, as well as from the regular meetings of the Society, is from no lack of interest. I watch the progress of the Society with rejoicing. I know well how much it is doing in many departments of natural history, awakening a deeper interest, and that the teachers of this community have derived the greatest possible benefit from the efforts made by the Society for their advantage.

Accept, if you please, the enclosed: [a check for $200] one-half for such additions to the library as may be thought best, and one-half to aid in the noble arrangements you have made, and are more and more fully perfecting, to assist the teachers of our schools in their work of instructing the young under their care in a true knowledge of the great works of nature.

With high regard and best wishes,

Very truly yours,

R. C. WATERSTON.

The President expressed the thanks of the Society for this generous gift from the Rev. Mr. Waterston.

Mr. S. H. Scudder read a paper[1] on the introduction and spread of the cabbage-butterfly through North America, from 1860–1886.

GENERAL MEETING, MAY 18, 1887.

Vice President, Dr. G. L. GOODALE, in the chair.

The following resolution was offered by the Council.

Resolved: That the grateful thanks of the Society be offered to Mr. Samuel H. Scudder for the great interest he has taken in its work during the seven years he has presided over the Council, directed the proceedings of the general meetings, and aided and encouraged the several officers in their various duties. That the long continued association of Mr. Scudder with the Society, in different capacities, including the offices of Curator, Librarian and Secretary, previous to the last high office, which it was equally honorable to the Society to give, and to him to accept, has so effectually bound him to us that every member will continue to look to him for advice, with the feeling that his interest in the welfare of the Society will be as great in the future as it has been in the past.

The resolution was unanimously adopted.

Mr. J. H. Emerton described the structures and habits of the Ciniflonidæ, showing twine models of their webs.

The following paper was presented:—

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[1] Printed in the Memoirs, Vol. IV, p. 53.

PRELIMINARY REMARKS ON THE STRUCTURE OF THE SIPHON AND FUNNEL OF NAUTILUS POMPILIUS.

BY HENRY BROOKS.

THE shell of Nautilus pompilius has, besides all the ordinary shell layers, a tube connecting all the air chambers together and opening into the living chamber. This tube is the covering of the fleshy siphuncle and will be spoken of as the siphon, as is customary among palæontologists and conchologists, and this paper is written to describe its structure in detail.

The siphon commences in the first chamber as a cæcum. The closed end rests against the inner surface of the apex of the shell in a cup-like depression that is generally situated over the scar, but is often found a little on either side of it. This has been ascertained by examining more than thirty shells of Nautilus pompilius. The siphon consists of a series of tubular sections extending from septum to septum and increasing in diameter as the chambers expand. Each section is made up of two parts, an outer calcareous sheath and an inner tube of conchiolin. The outer sheath extends from the inner surface of a posterior funnel of one septum to and embracing the outer surface of the anterior funnel of the next septum. The inner tube extends from the inner surface of a posterior funnel to the outer edge of an anterior funnel.

The outer sheath is made up of calcareous spicules overlying one another and arranged in such a way as to form an exceedingly porous structure. Numerous small openings may be seen in its wall with a low power, and a fluid when poured in above any septum rapidly permeates the wall of the sheath and runs down its outer surface into the chamber below. The spicules are fusiform and as a rule are arranged in stellate figures. There are irregular holes or cavities on the outer surface of the sheaths. These cavities do not extend through the sheaths but are partially closed by the spicules forming the middle portions of the sheaths, which are more closely interlaced than those forming the outer surfaces. The spicules that extend beyond the outer surfaces of the sheaths often terminate in irregular knobs, many of which are covered with slender bristles or spikes, giving the knobs an appearance similar to that of a chestnut burr. Others are hollow at the centre terminating in concave discs, made up of slender sticks or bristles radiating from the hollow of the main shaft. The pin-shaped spicules also occur on the inner surface of the sheaths, but here they are smooth and without the bristles, and somewhat flattened on their ends where they rest against the conchiolin tube. The spicules forming the inner layer of the sheaths are almost wholly fusiform, or of some slight variation from that shape.

In the extremely young siphons, including the cæcum, the sheaths are made up of slender threads, placed in the same way as the spicules of the older sheaths.

There is no regular arrangement of the spicules except at such points on the anterior portions of the funnels where the siphuncle rested. Here they are placed at right angles to the surface of the funnel. The same arrangement is found in the spicules forming the disc-like bottom of the cæcum. Here they are placed at right angles to the inner surface of the apex of the shell.

The spicules are made up of slender transparent sticks of calcareous matter, much smaller than the threads forming the young sheaths but still similar to them. These transparent sticks are held together in bundles by organic matter. These, when examined under a high power, have the appearance of bundles of fagots. In the older sheaths the bundles are yellow, while in the extremely young ones they are white.

The spicules of the anterior portions of the sheaths where they embrace the funnels, are much smaller than those of the posterior portion and often appear as mere granules. At this point the sheaths are marked with a series of ridges extending around their entire surface. These ridges are much deeper and more pronounced on the dorsal or inner side of the sheaths than on the ventral or outer side. The ridges indicate a series of interruptions in the growth of the sheaths and the commencement of the formation of new septa.

The sheaths of the older siphons commence as a dense layer situated on the posterior inner surface of a funnel. This dense layer extends through the funnel for a short distance when it at once assumes the open structure which is retained throughout its entire length.

There seems to be a well marked period in the growth of the siphons when they first commence to form spicules, but this, as yet, has not been fully determined. The formation of sheaths of the young siphons will form the subject for another paper, when it has been fully examined.

The conchiolin tube commences as a closed sac fitting into the sheath of the apical chamber. It extends unchanged in thickness through the first funnel. From the second to the fourth septum the tubes are much drawn out and attenuated so as to be transparent at the points where they pass through the funnels. At the fifth or some subsequent septum, the exact number of which has not been fully ascertained, a change takes place and the tubes no longer pass through the funnels but are disconnected.

They extend from the posterior inner portion of one funnel to the outer posterior edge of an anterior funnel. The anterior ends of the tubes are often forked and embrace both the outer and inner edges of an anterior funnel. The funnels of the young septa are much longer in comparison to the depth of the chambers than are the funnels of the older septa. The older funnels diminish in length as the chambers increase in size. They are made up of five layers:

(1) An outer layer formed by the anterior end of a posterior sheath, where it embraces the funnel.

(2) A darker and denser layer than the outer layer which contains more organic matter.

(3) The shell layer of the funnel proper.

(4) The dense layer forming the posterior end of an anterior spiculous sheath.

(5) An inner layer that is extremely short and reduces the opening of the funnel at its posterior end. This inner layer shows in section as a semicircle.

The last two layers are not present in the funnel of the living chamber.

The formation of the funnels of the young septa will be described in another paper.

EXPLANATION OF PLATES.

Plate 1. A longitudinal section of an older funnel showing the five layers, and a portion of the anterior and posterior spiculous sheaths and conchiolin tubes.

Plate 2. A diagram explaining Plate 1.

a. Anterior end of a spiculous sheath where it embraces a funnel.

b. The dense layer between the sheath and the shell layer of the funnel.

c. The shell of the funnel.

d. The dense end of a posterior sheath before it becomes spiculous.

e. Dense layer that reduces the opening of the funnel.

f. Anterior portion of a conchiolin tube.

ax. Posterior end of a sheath showing how it fits into the funnel.

fx. Anterior end of a conchiolin tube showing where it joins the posterior end of a funnel.

GENERAL MEETING, NOV. 2, 1887.

The President, Prof. F. W. PUTNAM, in the chair.

After calling the meeting to order the President welcomed the members to the Society's hall once more, and hoped that the papers announced for the evening foreshadowed an interesting season.

The President then spoke in fitting terms of the deaths, during the summer, of Ex-Vice President, Mr. R. C. Greenleaf and of Prof. S. F. Baird, an Honorary Member of the Society, and stated that notices of both members would be given at a future time.

The following papers were presented:

NOTES ON SOME TYPE-SPECIMENS OF AMERICAN TROGLODYTIDÆ IN THE LAFRESNAYE COLLECTION.

BY ROBERT RIDGWAY.
Curator Department of Birds, U. S. National Museum.

HAVING been kindly permitted by the authorities of the Boston Society of Natural History to examine the type-specimens of a number of Lafresnaye's species belonging to the genera **Campylorhynchus** SPIX, **Thryophilus** BAIRD, **Thryothorus** VIEILL., and **Troglodytes** VIEILL.,—species for the most part involved in more or less uncertainty,—it affords me much pleasure to present herewith the results reached by the examination in question.

1. **Campylorhynchus brunneicapillus,** Rev. Zool., 1846, 94. (**Picolaptes brunneicapillus,** Mag. de Zool., 1833, Ois. pl. 47.) Type, No. 2600, "California."

This specimen agrees exactly with examples from the southwestern border of the United States (Texas to San Diego, California) identified as *C. brunneicapillus* by Professor Baird and other American writers, and is therefore not *C. affinis* XANTUS, as suggested by Mr. Sharpe (*cf.* Cat. B. Brit. Mus. vi, p. 196).

2. **Campylorhynchus unicolor** (Rev. Zool., 1846, 93). Type, No. 2598, Guarayas, S. W. Brazil.

3. **Campylorhynchus unicoloroides** (Rev. Zool., 1846, 316). Type, No. 2599, Bolivia.

The former of these two specimens is in decidedly abraded plumage, with the edges of the greater wing-coverts, remiges and rectrices, faded and very obviously worn. This may account for the entire absence of the somewhat indistinct lighter and darker spotting which characterizes the edges of these feathers in the type of *C. unicoloroides*, in which the head and neck and the edges of the secondaries have a very strong fulvous-buffy tinge, the plumage being in very fresh condition. A specimen in the National Museum collection from southern Brazil (No. 16439, ♀ ad., August, 1858, Chr. Wood) is decidedly nearer the type of *C. unicoloroides*, in coloration, notwithstanding the feathers are somewhat worn. The measurements of the three are as follows:—

Type of *C. unicolor:* wing 3.35, tail 3.35, exposed culmen .80, bill from nostril, .58, tarsus, 1.05.

Type of *C. unicoloroides:* wing, 3.55, tail 3.40, exposed culmen, .85, bill from nostril .58, tarsus 1.00.

No. 16, 439, U. S. Nat. Mus.: wing 3.55, tail 3.55, exposed culmen .82, bill from nostril .60, tarsus, 1.10.

4. **Campylorhynchus brevirostris** (Rev. Zool., 1845, 339). Types, 2609, Bogota, and 2610, "Mexico."

These two specimens, which are very much alike, and both probably from Bogota, are undoubtedly the young of *C. zonatoides*, Lafr. (Rev. Zool., 1846, 92).

5. **Campylorhynchus zonatoides** (Rev. Zool., 1846, 92). Types, Nos. 2606, "Mexico", 2607, "Columbia," and 2608, "Columbia."

These are all adults, and agree substantially with Bogota specimens in the National Museum collection.

6. **Campylorhynchus palliceps** (MS. only?). Type, No. 2614, "Mexico."

This specimen agrees minutely with the type of *C. balteatus* Baird (*cf.* Review Am. B., 1864, p. 103, in text), the habitat of which is western Ecuador and Peru.

7. **Campylorhynchus pallescens** (Rev. Zool., 1846, 93). Type, No. 2613, Lafresnaye collection; "Mexico."

This is not the Mexican species usually known under this name (*i. e.*, *C. megalopterus* Lafr.), but a very distinct one, allied to *C. balteatus* Baird, from western Ecuador and Peru. From the latter it differs in lighter coloration, the darker markings dusky grayish brown instead of blackish, and white bands across remiges about equal in width to the dusky bands instead of only about half as wide; breast narrowly barred or transversely lined, instead of spotted, with dusky; middle tail-feathers sharply banded entirely across with dusky grayish brown and very pale brownish gray. Wing 3.30, tail 3.50, exposed culmen .75, bill from nostril .52, tarsus 1.05.

The true habitat of this species is of course unknown, but, considering the fact that its nearest relative is *C. balteatus* BAIRD (*cf.* Review Am. B., p. 103, in text), it probably inhabits some portion of northern or western South America.

8. **Campylorhynchus megalopterus** (Rev. Zool., 1845, 339). Types, 2611 and 2612, Mexico.

While differing in some particulars, which are probably attributable to the more worn condition of their plumage, these specimens agree essentially with specimens of the so-called *C. pallescens* from Mexico. Compared with five adults of the latter, the differences are found to consist (1) in the darker spots on the lower parts, which are also less tinged posteriorly with pale brownish buffy, and (2) in the decidedly paler and less buffy lighter bars of the rump and upper tail-coverts.

In measurements they do not differ, as the following may show.

No. 2611: wing 3.50, tail 3.30, exposed culmen .80, bill from nostril .57, tarsus .95.

No. 2612: wing 3.70, tail 3.70, exposed culmen .90, bill from nostril .65, tarsus 1.05.

No. 32471, Nat. Mus.: wing 3.65, tail 3.25, exposed culmen .85, bill from nostril .59, tarsus 1.10.

9. **Campylorhynchus curvirostris** (MS. only?). Type, No. 2621, "N. Granada."

This is a small species allied to *C. brevirostris*, LAFR. and *C. zonatus* (LESS.), but apparently quite distinct from either, its characters being as follows:—

Campylorhynchus curvirostris, sp. nov. (*ex.* LAFR., MS.)

SP. CHAR.—Similar to *C. brevirostris* LAFR., but much smaller, with bill slenderer and more curved though proportionally wider at base, whitish bands of upper parts relatively broader, tail much more distinctly banded (the middle feathers banded entirely across) and strongly tinged with dull buffy or fulvous, and spots on lower parts much smaller, those on throat and chest decidedly longitudinal, the belly immaculate buffy. Total length (mounted specimen) 6.50, wing 2.80, tail 3.10, exposed culmen .75, bill from nostril .55, tarsus 90.

The measurements of five adults of *C. brevirostris* are as follows: length (mounted specimens) about 7.00–7.30, wing 3.20–3.45, tail 3.40–3.60, exposed culmen .65–.85, bill from nostril .55–.60, tarsus .95–1.00.

10. **Campylorhynchus minor** (MS. only?). Type, No. 2620, locality unknown.

This is a young bird in first plumage, and belongs to the same group as *C. nuchalis* Cab. and *C. pardus* Scl. It may be referable to one of these two species, but this I am unable to determine from the material at hand.

11. **Thryothorus rufalbus** (Rev. Zool. 1845, 337). Type, No. 2647, "Mexico."

This specimen is clearly a typical example of the northern (Guatemalan) race which Professor Baird named *Thryophilus rufalbus*, var. *poliopleura* (*cf.* Review, pp. 128, 129), which name must therefore sink into a pure synonym of *T. rufalbus*. There is in the Lafresnaye collection another specimen marked as type of *T. rufalbus* (No. 2649, "Columbia"); but since only "Mexico" is mentioned as the habitat in the original description, which furthermore agrees exactly in all essential points with the so-called Mexican specimen, there can be no doubt as to which is really the type. Unless the name *Troglodytes cumanensis* Cab. (J. f. O., 1860, 408, *ex* Licht., MS.) is found to be applicable to the southern form, I do not know of any available name for that subspecies. According to Cabanis (*l. c.*), *T. cumanensis*, which is from Cartagena, differs in several respects from the ordinary bird from the interior of Columbia (Bogota, etc.); and if this proves to be really the case, the name in question should be restricted to the coast form. Pending the decision of this question, it may be well to provide a provisional name for the bird which Professor Baird considered to be the true *T. rufalbus*, the range of which extends from Nicaragua to the highlands of Columbia, and I therefore propose for it that of *Thryophilus rufalbus castanonotus*.

12. **Thryothorus maculipectus** (Rev. Zool., 1845, 338). Type, No. 2657, "Mexico."

This specimen is identical in coloration with Mexican examples in the National Museum collection; hence, the allocation of the name in a restricted sense to the Mexican form, as has been done in my *Manual of North American Birds* (p. 552), is correct.

13. **Thryothorus ruficeps** (MS. only ?). Type, No. 2659, Brazil.

This is *T. felix* SCL., and is therefore probably from Mexico. In the color of the sides and flanks, this specimen agrees exactly with Professor Baird's description (*cf.* Review, p. 136) of a specimen from Oaxaca in Mr. Salvin's collection, the color being "a shade of brownish, paler than the back," and *also with the colored figure in the Biologia Centrali-Americana* (*Aves*, pl. VII, 1). Four Mazatlan specimens in the National Museum collection, however, have the sides and flanks a deep and decided buff, totally different from the color of the back. Were this difference in the color of the sides and flanks constant, the birds from Mazatlan would be very readily separable from those from Oaxaca; but that the latter vary in this respect would appear from the fact that Dr. Sclater's original description (*cf.* P. Z. S., 1859, 371) of the species describes the color of the under parts as being "*cinnamomeo-rufescens, ventre medio pallidiore, gutture albo*," while Mr. Sharpe (Cat. B. Br. Mus., VI, p. 232) says, "sides of the body and thighs fawn-buff."

14. **Thryothorus fasciato-ventris** (Rev. Zool., 1845, 337). Type, No. 2658, "Bogota."

This specimen differs from Mr. Sharpe's description (*cf.* Cat. B. Br. Mus., VI, pp. 229, 230) in having the entire breast barred with whitish, there being no uniform black band as described or as shown in the colored figure on plate 14 (fig. 1). In fact, both the latter and the description agree essentially with a specimen from the Isthmus of Panama in the National Museum collection (No. 53897, ♂, McLeannan), which again differs from an adult male from Santa Marta (No. 34095, Nat. Mus.,) only in having the dusky (not "grayish black") of the ear-coverts and the uniform black of the breast rather more extended, the thighs more distinctly barred with black, and the under tail-coverts more narrowly barred with white, the whitish bars on the sides, flanks, and abdomen being also rather less distinct. According to Mr. Sharpe's views (*l. c.*), the Panama bird should be *T. albigularis* SCL. (*Cyphorinus albigularis* SCL., P. Z. S., 1855, 76, pl. 88), but the original description of the latter makes no mention of uniform black on the breast, while the colored plate shows distinct white bands over the whole breast as well as the more posterior lower parts, these white bars being at the same time altogether broader than in any example of the species (in its comprehensive sense) that has come under my notice. In other words, there is far greater resemblance between the Panama and Sta Marta specimens than between the latter and the type of *T. fasciato-ventris*, and quite as much resemblance between either of the former and two examples of the Veraguan and Costa Rican form (*Thryothorus melanogaster* Sharpe, Cat. B. Br. Mus., vi, p. 230, pl. 14, fig. 2), in the National Museum collection (Nos. 61966, ♀ ad., Bugaba, Veragua; E. Arce, and 42808, ♂ ad., San Mateo, Costa Rica; J. Cooper), the two latter agreeing with the Panama and Sta Marta specimens in having the whole breast uniform blackish and the upper parts a rich rusty brown or chestnut, instead of a much lighter and more fulvous brown. *T. melanogaster* may, however, be distinguished by the pale rusty brownish instead of white bars on the under tail-coverts, and much less distinct (sometimes quite obsolete) bars on the sides, flanks, and abdomen. There can be no question, however, that this form grades directly into the Panama form, which in all probability is only a local race of *T. fasciato-ventris*. If this view of their relationship be correct, the three would stand respectively as *T. fasciato-ventris* Lafr., *T. fasciato-ventris albigularis* (Scl.), and *T. fasciato-ventris melanogaster* (Sharpe).

15. *Troglodytes tecellata* (Lafr. & D'Orb., Mag. de Zool., 1837, cl. ii, p. 25). Alleged types, Nos. 2692 and 2693, "Peru."

It is very doubtful whether these are really the types of this species, since they do not agree in all respects with the description. Of one thing, however, there can be no doubt, viz., that they are identical with *T. brunneicollis* Scl.! Compared with four examples of the latter from southern Mexico, they are found to agree in the minutest particulars as regards form, size, and coloration, in which respects they are entirely unlike any South American species of the genus. Not only are the under tail-coverts, but also the entire flanks, barred with dusky and whitish (only the tips of the flank-feathers being of the latter color, the basal portion being pale fulvous or buffy); the middle wing-coverts have minute terminal white spots; the head a broad and conspicuous buffy superciliary stripe sharply contrasted with the brown pileum and postocular stripe, and the anterior and lateral lower parts are deep tawny-buff, becoming much paler on the belly. Their measurements are as follows: Total length (mounted specimens) 4.00–4.20, wing 2.00–2.12, tail 1.70–1.80, exposed culmen .48, bill from nostril .35, tarsus .75.

U. S. National Museum,
July 6, 1887.

A NEW MODE OF LIFE AMONG MEDUSÆ.

BY J. WALTER FEWKES.

SEVERAL pamphlets and one or two books have been written on the influence of parasitism in the modification of animal structure. Perhaps nowhere do we find this mode of life better illustrated than among certain of the Crustacea, where the anatomical structure is so masked by their parasitic habits that for a long time in the history of research it was impossible to recognize their zoölogical affinities, and it was only when the immature stages in the growth were studied and larval conditions, unaffected by parasitism, had been investigated, that the true relationships of the group could be discovered.

What we find in the so-called Lernean worms exists wherever parasitism is found among animals. It may, in fact, be concluded that ordinarily in parasites there is a degradation in structure, or at all events such a modification as to lead to important changes in anatomy and external form.

It would seem that among the lowest animals we ought to find a larger number of parasitic genera than among the higher. While there is little doubt that there is more variety in lower animals, I am not so confident that this mode of life has led to as great modifications in structure here as might be expected. While we cannot ascribe to parasitism the many variations in animal structure which occur, and it is impossible to give this mode of life a primary importance in theories of origin of species as has been attempted, it is no doubt true that many variations in structure have been derived either directly or by heredity from parasitic ancestors.

Nowhere among lower animals is there more likelihood that we should find parasitic conditions than among the Medusæ. Reflect for a moment that the young of a majority of these animals live attached to submarine objects, and it seems easy to see how by changing its habitat a parasitic attachment to another animal might easily take place. Considering the probabilities, however, although the number of genera which might be mentioned as living upon other animals is large, the number of recorded instances of those which have suffered a modification in structure by their attachment is very small.

Everyone who has taken a hand in the most fascinating part of the study of marine zoölogy, viz., dredging in the ocean, knows how often ascidians, brachiopods, large mollusks and other animals are brought up with attached hydroids growing upon them. These hydroids, in one sense, are not parasitic, as they draw no nourishment from their hosts, nor are they at all modified by their mode of life. For instance, Hydractinia, from a Natica shell inhabited by a hermit crab, is not unlike Hydractina from the underside of a floating bell buoy. Obelia from the stalk of Boltenia is specifically the same as Obelia on a submerged log. In these and similar instances, for they are numerous and varied in nature, there is no resultant modification either of host or parasite, as the attachment is in no way vital or intimate.

There are, however, among the Medusæ, certain recorded cases of parasitism where there is a vital connection so to speak, where there is a parasitism or even commensalism of such an intimate character that not only the structure of the parasite, but also even that of the host itself is modified. It is a study of these cases which has a most interesting morphological importance, for it affords, in some instances, at least a means of estimating the modifications of structure which may result in Medusæ from parasitic habits. They introduce into the discussion of the theory of evotion a series of facts which may well be carefully considered by those who ascribe to selection an all-important factor in the modification of animal structure.

It is not my purpose, however, to enter into a discussion of this subject upon which so much has already been said by abler naturalists than myself. I have simply introduced it in preparation for the consideration of new observations bearing upon the question among the jelly-fishes. Let me, as an introduction, mention a few instances of modification of Medusan genera by the mode of life called parasitism.

One of the best known instances of parasitism among Medusæ is that of Cunina which lives parasitic in the stomach of another Medusa, Geryonia. We, undoubtedly, have, in this case, a modification of the parasite by its peculiar mode of life in the host, although a reciprocal effect on the host is not recognizable.

Less known than Cunina, although quite as interesting, is that of

Mnestra parasita, a Hydromedusa which lives parasitic on the pelagic mollusc, Phyllirhoe. We find here a modification in the structure of Mnestra by the attachment, although we know but little of the nature of that modification, while of the growth of the medusa we know nothing.

A most interesting instance of parasitism, and consequent modification among Medusæ, is found in the problematical organism, Polypodium. This undoubted hydroid is found parasitic in the ova of the sturgeon while in the body of the fish. We have in Polypodium, as described by Ussow, a hydroid-like animal which develops and drops buds which can be directly compared with Medusæ. These are not the only instances of parasitic Medusæ thus far recorded, but they are typical and useful for comparisons. None of them are as valuable as they might be in estimating the amount of change in anatomy which has resulted, since we are either ignorant of their whole life-history or of that of related adults with simple development.

It is with the greatest pleasure that I am able to add to the above-mentioned instances of parasitism among Medusæ another of most extraordinary character. This instance is peculiarly adapted for the study of the effect of parasitism in modifying the Medusan structure, as its close allies are well known and comparisons with them can be easily made. This instance is, I believe, unique and the first recorded example of a hydroid living attached to the outside of a fish, and modified in structure by its life. It may thus properly be called a new mode of life among Medusæ.

In the pelagic fishing which has been carried on for the last ten years at the Newport Marine Laboratory we have taken several specimens of the well-known fish, Seriola zonata, Cuv. This fish is a close ally of the ordinary "pilot fish" and is often seen in calm weather swimming near the surface of the sea. Three of these fishes were found in company last summer, and upon the side, near the anal fin, of one of these, curious appendages were noticed which had never been observed before. On capturing the fish and making a superficial examination of the attachment, I was reminded of an attached fungus growth. Everyone is familiar with the growth on fishes of the fungus, Saprolegnia, and the resemblance seemed so great, except in color, between the supposed fungus of Seriola and Saprolegnia that at first I regarded the former as a fungoid growth. The color of the supposed fungus of Seriola was, however, reddish and yellow; and, although I have since learned that superficial fungoid growths of this color sometimes exist on fishes, at the time when Seriola was captured I was ignorant of this fact, the red color led me to doubt its fungoid affinities. A glance at the supposed fungus through a small lens easily dispelled my error and showed me that I had a new and unique case of a parasitic hydroid. It is to the peculiarities in structure of this animal and the medusa which was raised from it that I wish to call the attention of the Society this evening.

As the genus of hydroid which shows this curious mode of life is new, it will be necessary to assign it a name and I suggest that of Hydrichthys mirus as expressing one phase at least of the curious life which it leads.[1]

The majority of genera of Hydromedusæ have ordinarily two stages of growth, one of which is called the hydroid and the other the medusa stage. The latter is a medusa-form zooid of the former. Let us consider each of these stages in Hydrichthys.

Hydroid.—The hydroid of Hydrichthys consists of sexual and asexual individuals, both of which arise from a flat plate of branching tubes which is fastened to the sides of the body of the fish. The sexual individuals may be called the gonosomes, the asexual the filiform bodies.

The gonosomes consist of a simple contractile, highly sensitive axis, upon the sides of which are borne lateral branches with terminal clusters resembling minute grape-like bodies. These grape-like bodies are medusæ in all stages of growth. The filiform individuals are simple, flask-shaped bodies, without tentacles, and with terminal mouths.[2]

No circle of tentacles about a mouth opening was detected either in the gonosomes or the filiform bodies. This is a significant loss, since, with the exception of Protohydra, Microhydra, and the secondary zooids of certain Alcyonians, tentacles of some kind are found near a mouth or in relation to the oral opening of most of the fixed hydroids or polyps.

Medusa.—The gonophore of Hydrichthys has a Sarsia-like bell and manubrium, four radial tubes, four tentacles without appendages, as already elsewhere described by me.[3]

In the light of what we know of the affinities of the medusa of

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[1] An accurate diagnosis with figures will be found in my paper "On Certain Medusæ from New England." Bull. Mus. Comp. Zool., XIII, No. 7.

[2] Somewhat like spiral zooids in Perigonimus except this particular.

[3] Bull. Mus. Comp. Zool., XIII, No. 7.

Hydrichthys it is interesting for us to consider those of the attached hydroid. If our problem was to determine the relationship of Hydrichthys from a study of the medusa alone, we could easily conclude that it is a near relative of Sarsia. Such a conclusion is, I believe, one which can be easily defended. When, however, we come to compare the hydroid of Sarsia and the hydroid of Hydrichthys, we find the greatest differences between the two. These differences are so important that they have affected the whole structure; for a comparison of the two reveals the effect of the peculiar mode of life in Hydrichthys. The typical structure, or schema, of the tubularian hydroid, as Coryne, is a slender axis which may be naked or encased in a chitinous tube, an enlargement at the free end, and a terminal mouth opening. This mouth opening or the walls of the enlargement bear tentacles in rows irregular or otherwise. Somewhere among these tentacles, or elsewhere on the stem, arise buds which may or may not develop into medusæ. The widest variations from such a schematic type might be noticed among hydroids. Our purpose here is to compare Hydrichthys with the so-called schema.

In the case of the gonosome of Hydrichthys I suppose that the stem of the schema remains, that the terminal mouth opening is present, but that the enlargement of the axis has disappeared. From the sides of the axis arise lateral branches as in some hydroids and the medusa buds have been crowded to the distal ends of these branches. Tentacles have disappeared on account of the parasitic nature of the life of the hydroid. It is from this fact that we find in Hydrichthys the schema of the ordinary tubularian hydroid reduced to a simple sexual body or gonosome.

In the homology of the "filiform bodies" of Hydrichthys the reduction, as compared with the schema of a hydroid, has gone still further on account of the parasitic life, and nothing remains but a simple axis without appendages of any kind.

If I am right in this homology of the two kinds of individuals in the Hydrichthys colony, it would seem as if there ought to be a meaning for their simple structure as compared with the typical hydroid. The relation of the medusa to that of Sarsia-like genera would imply degeneration, not phylogenetic simplicity. Cannot we find in parasitism a cause for such a degradation?

Is the conclusion legitimate that these great differences between Hydrichthys and the fixed hydroid closely related to it are the result of its peculiar mode of life? I believe it is. I believe that the modification in the hydroid Hydrichthys, the loss of tentacles, the polymorphism, and the increase in prominence of the sexual bodies, are exactly what we should expect to find *a priori* if a degradation had taken place in its structure.

There is one other point to which I wish to call the attention of the Society before closing my communication. The existence of a polymorphism, such as we find in Hydrichthys, is exceptional among fixed hydroids of the tubularian group. Something similar exists in Hydractinia and Perigonimus and one or two other genera, but this kind of polymorphism is not common among fixed Hydromedusæ. A similar polymorphism exists, however, in Velella, a floating hydroid well known to all naturalists. In Velella we have the basal plate with anastomosing tubes of Hydrichthys modified into a complicated float. The gonosomes are the same in both genera, the filiform bodies of Hydrichthys are represented by the single central polyp, so-called, in Velella. The medusæ of the two closely resemble each other. There are only two kinds of individuals in both genera.

Strangely enough, after I had reasoned out this likeness between Velella and Hydrichthys, on morphological grounds, my memory went back to a strange story I had once heard from an Italian fisherman of the origin of Velella from the common mackerel. This story or a similar one long ago found its way into the books.

According to Marcel de Serres, the Mediterranean fishermen suppose that Velella originates as a bud from the head of the mackerel, and Pagenstecker goes on to explain this error, after quoting its source, from the fact that young Velellæ are often found in the nets with the fishes, and it is easy to suppose, as their color is similar, that one budded from the other. While we accept without question this explanation and the want of foundation of the fishermen's yarns, it is a strange coincidence that a possible relative of Velella should be found attached to the body of a fish. It is well for us to enquire, in the light of phylogeny, whether Velella, if it has not itself originated from hydroids on the fish by budding, has not been directly derived from one which is so intimately related to Hydrichthys, which is attached to the body of a fish, that an unskilled observer might be easily deceived.

Hydrichthys is, in point of fact, the nearest known ally of Velella among fixed hydroids, and their morphological likenesses have already been pointed out. It would be premature to suppose, however, that Velella has derived its peculiar anatomy from its descent from a form like the parasitic Hydrichthys, rather than that Hydrichthys is a parasitic descendant of Velella; while the acceptance of the last mentioned theory would lead us to regard fixed hydroids like Coryne as likewise descendants of parasitic forms with which they have few resemblances. Indeed, we know next to nothing of the egg and early growth of either Hydrichthys or Velella. We have at all events found in Hydrichthys a near ally of Velella as far as the hydroid is concerned, whatever may be the story told by the early history of both.

There is also another point long since known to those familiar with the literature of the Hydromedusæ, which is beautifully illustrated by Hydrichthys. Several naturalists have mentioned or called attention to the resemblance of the medusæ of hydroids of very different form. We may have medusæ so nearly related as to be placed in the same genus, but their hydroids would otherwise be placed in different genera. In Hydrichthys we have an illustration of this principle. The medusa is similar to Sarsia, but there is only a remote likeness between the attached hydroid Hydrichthys, and Coryne the hydroid of Sarsia. If a special student of the hydroids was called upon to identify the parasitic hydroid, he would consider its zoölogical distance from Coryne very considerable, but a study of the medusa would lead him to a somewhat different opinion of its zoölogical position.

Do these facts of a difference in the form of the hydroids of allied medusa-form gonophores, or *vice versa,* as sometimes happens, the diversity of medusæ derived from similar hydroids, mean anything morphologically? The question is an interesting one and admits of several interpretations which, however, it is not my purpose to consider this evening. There is one thing which has a bearing on the subject, which I wish in closing to say in this connection, viz.: *the true affinities of the majority of genera of campanularian or tubularian hydroids*, *or of Leptomedusæ and Anthomedusæ derived from the same*, *cannot be definitely made out until both hydroid and medusa are studied together.*

Papers were also read by Dr. W. G. Farlow on the conception of species in cryptogamic botany; and by Prof. Wm. M. Davis on the physical history of the Somerville slates.

General Meeting, Nov. 16, 1887.

Prof. W. H. Niles in the chair.

The following paper was read:

VALUES IN CLASSIFICATION OF THE STAGES OF GROWTH AND DECLINE, WITH PROPOSITIONS FOR A NEW NOMENCLATURE.

BY ALPHEUS HYATT.

In accord with views brought to the notice of the society in 1884, under the title of the "Larval Theory of the Origin of Tissue,"[1] an abstract of which was subsequently printed in Amer. Journ. Sci., May 31, 1886, we divide the animal kingdom into three comprehensive divisions: (1) Protozoa, unicellular animals, which propagate by means of asexual (autotemnic) fission and by spores, and build up colonies, but always remain typically unicellular. (2) Mesozoa, multicellular colonies, but composed of only one layer of cells, so closely connected, that they may be called a primitive tissue, and having more or less spherical forms.[2] They propagate by means of ova, spermatozoa, and by autotemnic fission,[3] and have an aula or common cavity, but no specialized digestive cavity or archenteron. (3) Metazoa, complexes of multicellular colonies, in which growth by sexual union, and resulting fission of the ovum, forms three primitive tissue layers and builds up a body in which an archenteron is always developed. They propagate always by means of ova and spermatozoa, autotemnic fission occurring only, if at all, during the earliest stages of the ovum. Holoblastic ova may be regarded as the more primitive or generalized forms to which all other forms of ova having more or less specialized and concentrated modes of development may be referred as derivatives. The stages of holoblastic ova may be in a general way classified as follows, to accord with that given above for the Animal Kingdom:

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[1] Proc. Bost. Soc. Nat. Hist., XXIII, 1884, p. 45.

[2] See Butschli's remark that the closely appressed hexagonal cells of the envelope are connected with each other by threads of protoplasm. Bronn. Thierreichs, I, Protoz., p. 775.

[3] The best summary of all observations is in the work just quoted, where Bütschli calls the sexual cells ova and spermatophora, but alludes to the cells developing by autotemnic fission as Parthenogonidia. They are by his own descriptions and those of others, ova, which differ from sexualized ova only in their ability to develop through autotemnic fission.

(1) The ovum or Monoplast (Lankester); (2) the first stage of segmentation, which normally results in the production of two cells in the same plane originated by vertical fission, the Monoplacula; (3) the second stage of segmentation in which two layers arise, the Diploplacula. The first two stages alone seem to have parallel or representative adult forms among Protozoa. The differentiation into esoteric (primitive ectoblast) and enteric (primitive endoblast) cells takes place in the Diploplacula, and the morphological equivalent of this stage of the ovum, having an upper layer of differentiated feeding cells, has not yet been found among the adults of the Protozoa; though, if this is correct, such a discovery may be reasonably anticipated. We have proposed to classify these stages under the name of Protembryo.

(4) The Blastula is in aspect and general characteristics the morphological equivalent of the adults of the genera Volvox and Eudorina, the types of the Mesozoa or Blastrea. The latter are animals in which growth remained permanently arrested at the single-layered, spherical stage in the evolution of tissue-building forms. We have proposed to classify these stages under the name of Mesembryo.

(5) The Gastrula can be compared, as has been done by Haeckel, with the lower Porifera (Ascones), but these have three layers like the lowest Hydrozoa, in which a three-layered gastrula-like stage has been permanently preserved.[4] The proper name for these stages would therefore be Metembryo, in allusion to the fact that the ovum at this stage is probably essentially a Metazoon.

(6) The first and simpler planula stages, though often characteristic of the larger divisions of the Animal Kingdom, would not, if arrested at this period, be recognized as belonging to the same

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[4] The true two-layered Gastrea type of Haeckel has, therefore, not been discovered. Doubtless, some such animals bridging the gap in the line of graded modifications between three-layered Ascones and single-layered Volvox will yet make their appearance, but we cannot consider any of the animals heretofore described as filling this gap to be entitled to such a position. They have all proved to be either three-layered, or else to belong to the true Mesozoa or Protozoa. See also for remarks on the prevalence of the three layers even in the gastrula, Metschnikoff, "Ueber gastrula einiger Metazoen" Zeitsch. Wiss. Zool., XXXVII, 1882, p. 305.

groups as their existing adults. They do not possess, as a rule, the essential diagnostic characters of the larger divisions to which they belong, and we propose to call them Neoembryos. Examples: the Cinctoplanula is not a sponge, the Planula of the Cœlenterata is not a Cœlenterate, nor the Pluteus an Echinoderm, nor the Trochosphere a Mollusk, nor the Pilidium a Nemertean worm, nor the earliest planula-like ciliated stages of Amphioxus a Vertebrate. Neoembryos are, as pointed out by Semper,[5] Lankester[6] and Balfour[7], so similar, that they may be considered as indicating a common ancestor for the entire Animal Kingdom.

(7) The latest of the more specialized planula-like stages are either directly transformed into, or else give rise to other forms in which the characters of the larger subdivisions or types of the Animal Kingdom begin to appear, at least so far as essential characters are concerned. Examples: the Ascula and Ampullinula are true sponges, the Actinula is a Hydrozoon, the Gulinula is an Actinozoon, the Veliger is a Mollusk, the internal worm-like form arising in Pilidium is a true Nemertean, the formation of the notochord in Amphioxus makes the planula-like embryo into a vertebrate animal. They have the essential characters of the larger subdivisions, though it is equally true, that embryos in this stage of development are very remote, in some cases, from the adults of any normal forms. We do not, therefore, misinterpret these relations by naming the embryo in these last stages the Typembryo.[8] This term can be applied to the Nauplius of Crustacea, and the Echinula[9] of Echinodermata, as well as to those above noted.

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[5] Semper, Stammsver. Wirbel. und Wirbellos., Arbeit. Zoolog. Zootom. Inst., II, p. 59, and III, p. 384. This distinguished author states in Volume III, that his "Trochosphaera" is identical with the "ungegliderte Urnierenthier," which in his first table in Volume II, appeared as the common ancestor of the higher animals, *i. e.*, of all animals except Echinodermata and Coelenterata.

[6] Lankester traced the Mollusca, Annelida, Rotifera and Echinodermata to what he calls the Architroch, a common form taken from somewhat earlier stages of the Planula than those selected by Semper for his Trochosphaera, Embryol. and Classif., Journ. Micros. Sci., XVII, 1877, p. 423.

[7] Balfour, Comp. Embryol., II, p. 311.

[8] From ῾Τύπος, type and ῞Εμβῦον, embryo.

[9] Alexander Agassiz, Address, Am. Ass. Adv. Sci., XXIV, 1880, p. 410, shows that there is a stage of the embryo common to all orders of living Echinodermata. This stage, however, was not named in the address above quoted, which was intended as preliminary to an illustrated essay on the same subject, and Mr. Agassiz has supplied that omission in the following note, which I quote from a letter to me. "I intended sometime when revising my 'Address on Palaeontological and Embryological Development,' to call the earliest common stage of echinoderm embryos, 'Echinula' for convenience in making comparisons.—A. Agassiz."

Typembryos serve to connect the earlier stages of the Neoembryos with the true larval stages which succeed the former. Balfour and other embryologists have used the term "larva" for free neoembryos and typembryos. This term should be confined to the designation of stages of growth which are immediately continuous with later stages and parallel, or referable in their origin to the adults of allied existing or fossil forms, which are not so remote as those from which the embryonic stages were derived.

The application of such principles to the study of the younger stages of fossil Cephalopoda is productive of what seems to be satisfactory results. The protoconch of Owen is, according to this nomenclature, the shell of the univalve veliger of the Cephalous Mollusca, and a true typembryo which, though eminently characteristic of that group, has no exact morphological equivalent among adults of normal forms whether recent or fossil.

The protoconch in fossil Nautiloidea is represented by a withered-looking lump sticking to the apex of the conch in a very few exceptionally perfect specimens. The very general absence of this lump and the presence of a scar left by its removal on the apex of the conch, and the wrinkled, shrunken aspect of the lump when preserved, indicate the protoconch to have had a horny texture in this order. This typembryo shell must have existed among Nautiloids with an almost unchanged aspect from the earliest Cambrian (Lower Silurian) horizon until the present day, and its adult equivalent probably existed before its appearance in Cephalopoda or in the equally ancient and allied group of the Pteropoda, which also had similar protoconchs.

The true larval, or as they are here named, Silphologic[10] stages, began with the formation of what Owen has appropriately called the apex of the conch or true shell. Among Nautiloids this was a short living chamber occupied by the body of the animal, but having no siphon or septum. It was completed by the deposition of the apical plate, which sealed up the aperture of the protoconch thus closing the opening and cutting off communication between the two interiors.

This stage can, therefore, be named the Asiphonula or siphonless larva. The apex of its conch was rounded, being built out in concentric circles from the contracted aperture of the protoconch, probably before this was plugged up by the deposition of the apical plate. The Asiphonula was not a Cephalopod, since it had no central siphon, nor even a septum. It may have resembled more or less closely the adults of some of the ancient Pteropoda. Von Jhering has thought, that the characteristics of the early stages of Ammonoids justified a comparison between them and forms of Pteropoda having similar Protoconchs. This was our own position also, but we now see, that the Asiphonula was not necessarily a wholly pteropod-like animal. It may have retained many of the veliger's characteristics, and may have more or less resembled a generalized type to which a Scaphopod is the nearest living approximation. Prof. W. K. Brooks'[11] opinion, that the Scaphopods are such a generalized type and that the veliger has characters which can be compared with those of the adult of Dentalium ought at any rate to be considered here.

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[10] Σίλφη, a grub.

It is not at all improbable, that the Pteropoda may never have served as radicals for the Nautiloids or Ammonoids, but the latter may have sprung directly from the ancient Scaphopoda.

The cicatrix naturally suggests comparison with the posterior opening in the shell of Dentalium, but if our view is the true one, and it represents the aperture of a protoconch, no such comparison can be made. The development of the conch in Dentalium is, according to Lacaze Duthier's researches, directly continuous with that of the protoconch, and the posterior opening is the result of the peculiar mode of growth of a primitive plate of shell which is never closed up. The shell, in other words, is a *periconch* growing around the body in the veliger and finally coalescing to form a tube open at both ends.

The second larval stage in Nautiloidea was composed of a living chamber closed apically and completed by a single septum, which had a cæcal prolongation reaching across the first air chamber and resting upon the inner side of the scar. It is proposed to call this stage the Cæcosiphonula, since it is undoubtedly the primitive stage of that organ. The cæcosiphonula may indicate the former existence of an ancestral form having a central axis composed of similar closed funnels or cæcal pouches.[12]

The third silphologic stage in Nautiloids was completed by a septum (the second in the apical part of the shell) having an open funnel extending apically and joined to a loose textured siphonal wall which reached down into and lined the cæcum, thus forming a secondary closed tube. In accordance with the structure this has been named the Macrosiphonula.

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[11] Proc. Bost. Soc. Nat. Hist., Aff. Moll. and Molluscoid., XVIII, 1876.

[12] See also similar remarks by Whitfield, Bull. Amer. Mus. New York, No. 1, and Embryol. Ceph. by the author, Bull. Mus. Comp. Zool., III, No. 5, p. 100.

The protoconch was present in Ammonoids and also in Belemnoids, but in both of these orders it was calcareous. The tendency to form a calcareous shell, which first appeared in the apex of the conch of the asiphonula in Nautiloids, became by concentration of development inherited earlier in the Ammonoids and Belemnoids in the veliger stage, thus transforming what would otherwise have been a horny shell into a calcareous one. The protoconch was, however, not otherwise changed in external aspect and retained the usual egg-like shape of the univalve veligers of the Cephalophora. As in the protoconchs of other similar veligers of Gasteropoda, etc., and as a result of calcification, the protoconch became fused with the apex of the conch more intimately than in Nautiloids. In other words the asiphonula, after transmitting a portion of its characteristics to the typembryos of the Ammonoids and Belemnoids, disappeared, having been replaced by the cæcosiphonula. The septum of the cæcosiphonula was consequently also inherited earlier, and became a functional substitute of the apical plate serving to close the aperture of the protoconch, and its cæcum extended into the upper part of the otherwise empty protoconch, in place of occupying the first air chamber as in Nautiloids. This is a remarkable example of the law of concentration, but by no means exceptional. The fourth larval stage of the Nautiloids was completed by the building of the third septum. This septum had a long funnel and attached porous wall, but the wall formed a true siphonal tube opening apically into the next section, the macrosiphon. This was the beginning of the small siphon and can be appropriately termed the Microsiphonula. The microsiphonula was the typical stage of nearly all the known genera of Nautiloids, beginning with the Orthoceratites of the Cambrian and found at the present time in Nautilus, and also in all Ammonoids and Belemnoids without exception.

Fortunately the genesis of both macrosiphonula and microsiphonula can be traced in the adult forms and silphologic stages of some well-known fossils. Crytocerina had a siphon which was macrosiphonulate probably even in the adult stage, since it increases in diameter throughout life. Piloceras had a huge siphon hardly at all contracted in the adults of some species, but considerably lessened in diameter during the same stage in others. Endoceras had also a large siphon always more or less contracted in the silphologic or later stages. The uncontracted macrosiphonula occupied in this genus a number of air chambers varying according to the species, from a few to six or more. This was evidently due to the earlier inheritance or concentration of the tendency to decrease the diameter of the siphon first manifested in the adults of Piloceras. Sannionites was a genus in which the siphon was smaller than in Endoceras, and probably, though this is not yet ascertained, inherited the tendency to microsiphonulation at the first septum at an earlier age than in Endoceras. None of these forms, however, attained a true microsiphon, since even Sannionites had the siphon filled by endocones and in the centre an endosiphon. These organs entirely disappeared in true microsiphonulate forms and, in fact, could have existed only within a large siphon.

Nevertheless this tendency to decrease the size of the siphon resulted in the formation of a definite constriction. This constriction was inherited at earlier and earlier stages after its origin in the siphon of Piloceras, until it became constant perhaps in Sannionites and certainly in the Orthoceratidæ. The constriction marked the line between the larger and smaller siphon in the macrosiphonulate forms, and, in becoming constant through concentration, it became invariably fixed behind the first septum, between the cæcosiphonula, and the smaller siphon. This smaller siphon though still a macrosiphon in structure as explained above, even in Sannionites, was undoubtedly transitional to the true microsiphons of the Orthoceratidæ.

The cæcosiphonula was in all Orthoceratites, which are otherwise similar to Endoceras, confined by concentration of development to the first air chamber, and a true microsiphonula appeared at an early stage as an open narrow tube. This was similar to the siphon of the vast majority of all succeeding forms of both Nautiloids and Ammonoids. According to the classification here advocated, the stages preceding the microsiphonula, viz.: the asiphonula, cæcosiphonula and macrosiphonula, became silphologic stages in all the groups of Cephalopoda descending from the radical Endoceratidæ. Microsiphonulation became silphologic in the Orthoceratidæ, and the smooth shell which they evolved was subsequently inherited among Nautiloids, Ammonoids and Belemnoids during the younger stages in all the species of these orders. Other forms, with depressed and involved whorls, were introduced in the main stock of radicals among Goniatitinæ, and were modifications of the smooth cylinder of the simpler Orthoceratidæ with its microsiphon. These in turn became the proximal radicals of derivative groups. Thus the Anarcestes[13] among Goniatitinæ became the radicals of the Ammonoidea, and the smooth silphologic stages of all Ammonoids after the expiration of the Devonian were like the adults of these lowest forms of Goniatitinæ. This later acquired silphologic stage has therefore been styled the Goniatitinula.

It has also been found that, in tracing the descent of forms within smaller groups, sub-orders, families, and genera, it is practicable, as in the case of the family of Endoceratidæ, to prove that characteristics usually appear first in adult stages and are then inherited at earlier and earlier stages in successive species of the same stock, whether they occur on the same horizon, or in different horizons. The adolescent or Nealogic[14] stages are of as great importance for tracing the genealogy of small groups as are the silphologic characters in larger groups. Thus one can speak in definite terms of the relations of the nealogic stages, and their meaning, and importance in tracing the genealogy of families and genera, without danger of confusing them with the characters of any of the silphologic stages.

After the silphologic and nealogic stages have been disposed of there still remains the adult period, which is equally important in genealogical investigations, since it enables the observer to study the origin of many characters, which afterwards become silphologic and nealogic in descendent forms.

It is not uncommonly assumed, that adaptive characters appearing in embryos and larvæ are apt to be transient and have but little effect on the subsequent history of the early stages in the same group; also, that such characters have appeared just as readily in the larvæ as in adults. Up to the present time this has not been found to be true among fossil Cephalopoda, and there exist, so far as known to the author, but few characteristics probably originating in the early stages. The constant recurrence of hereditary characteristics in silphologic and nealogic stages which originated in adults, like those given above for the Endoceratidæ, makes the probability of the assumption, that the asiphonula and veliger represent the adult stages of lost types, so highly probable, that the burden of proof must rest upon the opponents of this argument. Each case of the origin of characters in embryos and larvæ should in other words be regarded with distrust until proven.

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[13] Gen. Ceph. Proc. Bost. Soc. Nat. Hist., XXII, 1880, p. 305.

[14] *Νεαλής*, youthfulness.

The appearance of the incomplete modes of segmentation in existing Sepioidea may possibly be a case of origination in embryo. There are no adult forms known to the author, which store up food in their tissues in such a manner that they can be used to explain the origin of the specialized food yolk. Nevertheless special inquiry might have very unexpected results. The case above given of the calcareous nature of the protoconch, and all the other characters of this stage in the Ammonoids and Belemnoids, seemed to have originated in embryo until it was found that a distinct silphologic stage, the asiphonula, existed in Nautiloids, and that this indicated the former existence of an asiphonulate ancestor having a calcareous shell.

Some of the characters of the goniatitinula, such as the deep ventral saddle of the first septum in the angustisellate young, as described by Branco, doubtless originated in the younger stages. These are, however, correlative with the anarcestian form of this stage and with a general tendency to closer involution, which acted the same way in every series of forms, whether we select series of adults or of embryos for comparison.

The use of a distinct term for the adult period becomes necessary not only on this account, and to separate its relations from those of preceding periods, but also because of the constant recurrence and importance of representative forms. The term Ephebology[15] has accordingly been adopted for the designation of the relations of the adult stages, and under this term can be classified also the representation of similar forms in different groups or morphological equivalents. These are often so exact that it becomes very difficult to separate them. They have been and will continue to be the most difficult and misleading obstacles to the student of genealogy and classification.

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[15] Ἐφηβος, the age of puberty.

In former essays we have described and defined the senile transformations and their correlations with the degraded forms of the same groups. The nature of these relations is, as has been explained, quite distinct from those of the progressive and adult stages, but the correlations are nevertheless equally important for the classification and tracing of genealogies during the declining period of a group, and in the case of degraded and aberrant forms. We have, therefore, for some years past designated these relations by the term Geratology.[15]

This nomenclature is similar to that adopted by Haeckel, but is, when properly considered, also supplementary and based upon morphological rather than physiological grounds. This eminent author regarded the ontogeny of an individual to be divisible into three periods: first, the stages of Anaplasis or those of progressive evolution; second, the stages of fulfilled growth and development, Metaplasis; third, those of decline, Cataplasis. He also appreciated and gave full weight to the general physiological correlations which are traceable between the history of a group and the life of an individual, and, in accordance with these ideas, designated the progressive periods of expansion in the phylogenetic history of a group as the Epacme, the period of greatest expansion in number and variety of species and forms as the Acme, and the period of decline in numbers of species, etc., as the Paracme.

Haeckel used also the term Anaplastology for the physiological relations of the stages of progressive growth and those of the epacme of groups, Metaplastology for those of the adult and the acme of groups, and Cataplastology for those of the senile stages and the paracme of groups. These terms seem to cover the same ground as those we have employed, but they were in reality chosen for the purpose of classifying physiological relations. Thus the anaplastic relations of the embryologic, silphologic and nealogic stages to the phenomena occurring in the epacme of groups, and the metaplastic relations of the ephebolic stages to the phenomena occurring at the acme of groups, and the cataplastic relations of the geratologic stages to the phenomena occurring during the par-

[16] Γέρας, old age.

acme of groups, are the functional relations of one class of morphological modifications to those of another class and do not properly include the morphological phenomena themselves or their structural correlations.

The necessity for a double set of terms may possibly not be at first admitted by many zoologists on account of their too exclusive devotion to the morphological side of their studies, but a very slight experience in trying to express the serial correlations of morphological and physiological phenomena will very soon show them the convenience of such a nomenclature. Geologists have already arrived at this conclusion with regard to the classification of strata in the earth's crust and have begun to use two parallel series of terms one giving the nomenclature of the relations in time, era, period, age, etc., and the other the faunal relations under the headings of group, system, stage, and so on.[17] The time has come for recognizing a similar parallelism between structural or statical phenomena of organisms and their dynamical or physiological relations in time, and it is necessary to separate these clearly by different series of terms in order to see not only how they are separable, but also their correlations.

We have been more or less constantly observing and publishing on the geratologic stages among fossil Cephalopoda for more than twenty years and have repeatedly described the more or less exact comparisons, which can be made between the different stages of decline in the individual and the degraded forms occurring in the same group.

There were two stages in the old age period among Ammonoids: the first of these can be designated as the Clinologic[18] stage. This immediately succeeded the ephebolic period, and during its continuance the nealogic and ephebolic characteristics underwent retrogression. Ornaments, spines, and sutures degenerated and lost their angularity, the ribs or pilæ, and often the keel and channels, when the latter were present, became less prominent, and before this stage closed the whorl itself sometimes decreased, showing that degeneration in the growth force of the animal had taken place. Similar phenomena can be easily observed in other departments of the animal kingdom, notably in man, whose habits tend to preserve life until he has attained extreme age. During this period there is a steady loss of the differential characters acquired during the stages of progressive growth and there is a tendency to resume the proportions and aspect of the earlier nealogic stages. In man, baldness of the head, loss of teeth and resorption of the alveoli, loss of the calves, rotund stomach, and the return of early mental peculiarities, are phenomena of similar import.

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[17] G. K. Gilbert, Address, Am. Ass. Adv. Sci., 1887.

[18] Κλίνω, to incline downwards.

The last changes in the ontology of the animal may be termed the Nostologic stage,[19] and during this stage these tendencies reached their highest expression. Among Ammonoids the ornaments were all lost by resorption, the whorl became almost as round and smooth as it was in the silphologic stage, and in extreme cases it was separated from the next whorl, leaving a perceptible gap. This almost complete reversion to the aspect of the silphologic stage can of course only occur in animals which attain an extreme age.

The correlations of Clinology are exact, and indicate the changes which may be expected to occur in the same group whenever degraded or aberrant species can be traced in a more or less continuous series of graded modifications starting with any given normal form. Many such series have been traced, and these are recognized now by all paleontologists as genetically connected. They began with normal, close coiled, ornamented shells, the descendants were smaller, showing a tendency to be less involved by growth, to lose their ornaments, and simplify the outlines of the sutures, though they had coiled young stages similar to those of the normal forms from which they must have originated.

The correlations of Nostology can only be artificially separated from those of Clinology, but there existed one class of forms which can be compared only with the nostologic stage. These are the degenerate straight baculites-like shells, which belong to several distinct genetic series and should often be widely separated on that account. Their resemblances are undoubtedly close, but they are due to degeneration and, therefore, simply homoplastic. Naturalists sooner or later will begin to recognize that degeneration may produce close representation in forms having distinct origins. The Baculites is a smooth, straight, cylindrical though slightly compressed shell, which has so completely reverted that it resembles an Orthoceras, though it is an unquestionable Ammonoid of the Jura and Cretaceous.

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[19] Νόστος, a return.

Mr. S. H. Scudder gave an account of the means adopted by the butterflies of the genus Basilarchia for the perpetuation of the species.

GENERAL MEETING, DEC. 7, 1887.

Vice-President, Dr. G. L. GOODALE, in the chair.

Prof. N. S. Shaler read the following paper:

ORIGIN OF THE DIVISIONS BETWEEN THE LAYERS OF STRATIFIED ROCKS.

BY N. S. SHALER.

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It is a well-known fact that the greater part of our stratified rocks are divided into distinct layers or beds of varying thickness and generally of somewhat diverse composition. I am not aware, however, that the origin of these divisions has ever been made a subject of extended inquiry. The very generality of the phenomena has served to hide its importance. To a great extent our geologists have accepted the existence of stratified planes as something inherent in the nature of sedimentary deposits. Where they have sought an explanation of their existence, they have generally found it in presumed geographic changes though they rarely have been able to indicate the character of the change which has led to the institution of the divisions between the beds.

As a preparation for the study of the alterations which have occurred in the coast line of North America I have found it necessary to consider the effect of geographic change in producing alterations in the character of sedimentary deposits. It was obviously necessary to consider the evidence afforded by the successive layers of our sedimentary formations and to determine how far they could be taken as evidence of geographic change. Although these considerations are but a fragment of a considerable inquiry, they seem to me to have a sufficient importance to justify their presentation apart from the matter with which they will finally be associated.

The only part of this subject connected with stratification which has been made the matter of study is that which concerns cycles of deposition. Dr. Newberry and others have given us some very interesting studies on this point. I shall endeavor, however, to show in the sequel that, while these cycles of deposition afford phenomena of very great interest and are particularly valuable to those who are endeavoring to unravel the ancient geography of this continent, they constitute but a small part of the problem which we have to consider.

Divisional planes in rocks which have a bedded nature are clearly separable into two categories. First, those which are due to a change in the operation of forces which bring detrital materials to the point where deposition takes place. Secondly, to the operation of forces which in any way serve to make the deposition of this material irregular through the operation of conditions coming into action at the point where the deposition takes place. I propose to consider these causes separately, taking first those which are due to an alteration in the circumstances of carriage, by which the sediments were brought to the place where they were built into strata. The most familiar examples of change in this class occur in sandstones: the best illustrations are found in the ordinary cross-bedded rocks of this nature. In such cases it is easy to see that modifications in the run of currents may be due either to geographic changes of the neighboring shore lines or to alterations in the depth of the water in which the deposits have been made. Where the deposits have been brought to their site altogether by tidal currents the changes may be due to geographical changes at points very remote from the seat of the deposits in question. Thus in the case of the Mediterranean we have at present processes of deposition going on along the shores in which tidal currents have but slight influence for the reason that the tides in that basin are generally of trifling amount and with few exceptions give rise to but feeble currents. If it should happen that the tides of the Indian Ocean or those of the Atlantic were by geographic change freely admitted to this basin we should have a sudden change in the character of the sedimentary deposits formed along the coast lines it may be a thousand miles away from the point where the change itself occurred. So, too, geographical modifications may profoundly alter the height of the tide in any particular basin. Thus if the barrier which separates the Bay of Fundy from the Gulf of St. Lawrence should be lowered so as to afford a free passage to the tidal waves in that region, the result would be the great and immediate diminution in the run of the tides in that section. At the close of the last glacial period, during the time when the land remained depressed much below its present level, it seems certain that this passage was wide open and there are reasons to believe that the energy of the tides in the Bay of Fundy was much less considerable than at the present time, as is shown by the fact that the amount of cross-bedding exhibited in the stratified gravels at heights greater than that of the land which separates these two areas of water indicates a smaller amount of tidal action than is indicated by the strata now forming along the shore.

The change in the regimen of tidal currents is propagated to great distances from the point where the cause of the change occurs. Thus if Cape Cod should be cut through by the action of the tides, the effect in the run of the currents along the shore would be felt for many scores of miles in the direction in which the tide moves. In this way we may account for very many alterations in the direction of the bedding in our sandstones which have been due to the action of tides. Changes in the level of the sea floor on which sediments are deposited naturally induce profound differences in the character of the beds which are formed upon it. This result is brought about in either of two ways. In the first place, by bringing the point in question nearer to or removing it farther from the shores, the character of the sediments derived from the land is much altered. In the second place, the changes in the depth of water are apt to lead to a modification in the character of the organic life which enters into the formation of the deposits and thus produce a considerable modification in the nature of the sediments. As before remarked, several students have noted the fact that many cycles of change in rocks are to be explained by these alterations in the depth of the sea floor and consequently in the remoteness of the land. In general the process of subsidence is marked by a diminution in the amount of material derived from the land and a decrease in the average size of the grains which compose it. Where the alternation of level brings a deep-sea area to the condition of shallow water or the reverse, the range of variation brought about by the change of conditions is often very great and is shown not only in the character of the sediments themselves but in the nature of the organic fossils embedded in them.

Well-known instances of a wide swing in the conditions of organic life are afforded in our paleozoic sections. The most conspicuous of these is that which gives us the alternations between the Medina sandstone and the millstone grit. During the period of the Medina sandstone a large part of the region east of the Mississippi River was in the condition of a shallow sea. After it came a time of considerable depression in which the seas probably became several times as deep as they were in the Medina period. In the time of the Oriskany sandstone a good deal of the area was returned to the condition of shallow water. Then a profound subsidence occurred bringing a large portion of the area of the Appalachian district into the condition of deep sea during which the deposits of the Devonian black shale or Ohio shale were formed. After a long period in which this subsidence endured elevation the rocks again became more and more composed of coarse sediments until finally in the period of the millstone grit a large portion of the area became dry land or shallow sea. Every important step in these changes is distinctly marked by profound alterations in the character of the sediments.

We thus see that changes of elevation and the consequent variations of geographical relations may produce many important alternations of strata. There can be no question that geological science owes much to those who have developed the principle of cycle in sediments. At the same time geologists must recognize the fact that very important variations in the character of sedimentary deposits are not explicable in this way. Thus, if we come to the central portions of the Mississippi valley, we find a great succession of limestones composed of beds varying from a fraction of an inch to a number of feet in thickness each of which is separated from contiguous beds by a thin partition of clay. Examining any of these beds in detail we find that it extends horizontally for a distance of miles in every direction with more or less considerable variations in thickness. It is noticeable, however, that the variation in the depth of the clay parting is generally inconsiderable, usually indeed so slight as to escape detection. There is reason to believe that some of these clay partings, not over an inch in thickness, extend over many thousand square miles of area. It is manifestly unreasonable to suppose that these divisions can be explained on the theory of change in level. They evidently need to be accounted for in other ways. The very fact that they are so extensive and invariable shows clearly that they cannot be due to alterations in the nature of the sediments brought to the bottom by changes in the movement of tidal or other oceanic currents.

If we examine a typical section of stratified rocks, we perceive that beside the alteration in the physical character of the deposit is in most cases an important coincident change in its fossil contents. In the greater number of cases these clay partings are destitute of fossils. If they contain organic remains they are generally, in part, at least, of other species than those in the limestones which lie above and below. In many cases it can be observed that the limy matter slowly reappears in the layer above the clay, though in most cases it suddenly disappears in the layer below. It may thus often be noted that the upper part of a layer of a limestone abounds in well preserved fossils which project slightly from its surface, while the lower layer of the overlying limestone stratum exhibits no such distinct fossils. Those which it contains are more or less commingled with the clay matter.

At first sight the clay element of the partition between adjacent beds of limestone appears like a new material introduced into the section, but if we proceed to dissolve in dilute acid the lime from the layers of limestone, we find at the end of the process a residuum which is essentially like that composing the clay partitions. It is evident that the whole section is composed of a continuously formed deposit of clayey matter in which the lime element occasionally attains such prominence that the clay is hidden from ordinary observation. The clay is the steadfast element in the deposit; the lime laid down by the organic forms, the invariable element therein.

If the above conclusions are correct, then it is necessary for us to account for the sudden variations in the organic life on the sea floor which has led to the changes in the proportion of the limy element of the sediments. It is evident that this variation in the organic element of the rocks can best be explained by some cause or causes which may have led to the sudden death of the organic species, and, after a time, during which they did not contribute their remains to the strata, a tolerably swift reintroduction of the forms. As before noted, the lower portion of each bed commonly exhibits a somewhat gradual transition from the condition of clay to that of limestone, indicating a gradual passage from one state of the bottom to the other, while the upper part of the layer shows a sudden interruption in the organic life. The phenomena, as exhibited in the sections, would be exactly explained by any causes competent to destroy by one stroke the life over a wide field of sea. On such destructions taking place, the clay element would continue to be deposited though free from any admixture of lime. When, after a time, organic species found their way back to the field and gradually repossessed it, the limy element would be reintroduced into the strata. Postponing for the time our consideration as to the source of this clay element, we will proceed to consider the causes competent to bring about the sudden destruction of animals which lived on the sea floor over a wide field of that area.

We know as yet little of the causes which are competent to produce sudden destruction of organic life on the sea floor. We may, however, by a careful consideration of the known facts logically arrive at certain conclusions which appear to me to be important. In the first place we perceive that these destructions which bring about the termination upwardly of a limestone layer come suddenly over a wide field and that they affect a great number of the species living on the floor. We may, therefore, assume that this death is caused not by any disease affecting the creatures, but by some external physical accident. It seems to me that such an accident is explained by earthquake shocks. In the first place it is manifest that earthquake shocks affect the sea floor with something like the frequency and intensity of those which operate on the land. This is shown by the waves in the sea water which are produced by such commotions. The amplitude of the wave itself clearly indicates that the range of movement in the disturbance is often as great as is ever observed on the surface of the land. At their origin the waves which have repeatedly swept in upon the coast of South America cannot have an altitude of less than three feet and at times the movement may have amounted to as much as five feet. Within the limits of human history we have known of some scores of these accidents affecting the different portions of the ocean basins. They do not appear to occur in the North Atlantic, but the greater part of the shores of the other great water areas have felt their impulse.

The effect of a movement on the sea floor having an amplitude of a foot or more would probably be disastrous to the greater part of the organisms which inhabit the bottom. The rate of vibration of the water and the subjacent earth would be diverse. The result would necessarily be that friction would occur between the floor and the overlying water. This would tend to stir up the incoherent material on the bottom of the sea and to make the water unsuitable for the use of organic life. It is a well-known fact that the greater portion of our marine animals are singularly intolerant of muddy water, even if the quantity of dissolved mud be relatively inconsiderable. The forms which normally live on mud bottoms are to a great extent provided with contrivances which enable them to meet such accidents by peduncles or stems which lift their bodies some distance above the floor, by siphons, or by shells which may be closed during the period when they are subjected to risks of this sort. In the deeper seas, these provisions do not generally exist and the animals dwelling on the bottom are, therefore, very likely to be overwhelmed by such catastrophes. I am, therefore, inclined to believe that the sudden terminations in the organic contents of our layers, in stratified rocks formed on floors in the deeper seas are to be in the main accounted for by the action of earthquakes in stirring the mud. Some portion of the destructive influence may be exercised through the direct effect of the shock itself. It is a well-known fact that an earthquake shock is competent to destroy our fishes. The effect of jar on the invertebrate animals has never been investigated, but it seems not improbable that they too may be destroyed by such accidents. In the case of fishes the destruction effected by earthquake shocks is often extremely extensive, as has been noted by various observers. Several bone-beds, composed of fish remains which occur at various points in the geological section, may, perhaps, be explained in this manner. It is difficult, indeed, in any other way to account for such a deposit of bones as that which occurs in the Rhaetic deposits of Europe, where over an area of several hundred thousand square miles we find a bone-bed at a particular level which appears to indicate a widespread and simultaneous destruction of these forms.

It is very desirable that we should secure a series of experiments designed to determine the effect of explosive shocks on invertebrated animals, but it is not necessary for our purpose, for the reason, that the muddying of the water which would inevitably result from a powerful shock will be quite sufficient to account for the destruction of organic forms which we seek to explain. Nearly every part of the sea bottom has considerable amount of incoherent material which will be shaken into the water by an earthquake disturbance. Even where there is no other source of sediment than the organic remains themselves, the bottom is covered with a sheet of ooze. By far the greater part of the organic remains, deposited on the sea floor, fall into the condition of mud or are brought into that state by the action of creatures, such as our boring worms, which obtain their subsistence from the hard parts of various dead creatures. A very slight annual contribution of such material maintains a considerable depth of incoherent matter which is only gradually converted into deposits of such solidity as will resist the action of an earthquake shock and not be shaken up into the water.

Observations on our crinoidal limestones serve to confirm the foregoing hypothesis. It is well known that where strata are mainly composed of the remains of crinoids the beds are usually very much thicker than those which are formed of mollusks. The reason for this is plain. The crinoidal species are in most cases supported on flexible stems of considerable height. In many cases the sea floor, particularly in the sub-carboniferous period, appears to have been covered by vast groves or thickets of these animals, the stems standing almost as close as those of wheat upon a field. When subjected to an earthquake shock it is not likely that these creatures would be seriously damaged. Their elastic stems would in a measure protect them from the direct blow and as their mouths were elevated several feet above the plane of the bottom, it is not likely that the invasion of mud would have any considerable influence upon them. At various points we may observe where apparently an invasion of mud has somewhat affected the various lowly forms of life which dwelt upon the bottom in the spaces between the crinoid columns. Still the principal element of the sea floor life, the crinoids themselves, have maintained their existence and prevented the formation of a layer of pure clay where otherwise such deposits would have been made.

Again where the limestone deposit is made by the remains of floating animals, and is dropped to the bottom as is probably the case with a part, at least, of our chalk deposits and also with the deposit now forming on what has been termed the telegraphic plateau of the North Atlantic, the accumulation is not arrested by any disturbance affecting the sea floor. It thus may come about that very massive limestone strata are slowly deposited.

Where a series of limestones, originally in the bedded form, has been extensively metamorphosed, the process of change often brings about a consolidation of the whole mass. The clay is infiltered with lime to such an extent that the beds of it appear only as discolored portions of the whole section and not as distinct partitions. It is not to be denied that there are other possible actions which may serve to produce partitions in the rocks, but the one above suggested seems to be the most likely cause which is known to us to be of an efficient nature.

In our ordinary limestones of paleozoic age the average number of successive limy layers and shales may be counted as about four to each foot in depth or in such a succession as the Trenton limestone which may be called fifteen hundred feet in thickness there may be as many as six thousand of these divisions. It seems not unreasonable to suppose that in a period which continued as long as the Trenton this number of earthquake shocks may have affected an average sea bottom. Moreover this hypothesis will account for the interesting though little observed fact that the number of these divisions in a given thickness of strata varies greatly in different portions of the world. Thus we may find in one region the divisions of the strata amounting to as many as six to the foot, while in another region a thousand miles away the divisions may not exceed one to the foot of depth. From all we know of earthquake action we may fairly presume that the liability to shocks in particular regions has varied greatly and thus a variation in number of the partition planes would be brought about. It may indeed be the fact that in certain regions a geological period may go by without any shocks of decided violence on the sea floor. Thus in the North Atlantic there seems to be in the present period a notable exemption from submarine disturbances of a seismic nature. Some recent studies which I have made on the kame deposits along our American shore clearly indicate that no inundating waves such as are produced by earthquakes have rolled upon the coast of New England since the shore assumed its present level. We cannot well estimate the continuance of the present level along that shore at less than ten thousand years; it probably exceeds twice that period, as is shown by the amount of cutting done by the sea along the rocks which are now exposed to wave action. For this great period of time the delicate kames which extend down to within twenty feet of high-tide mark have been exempt from such invasions of swiftly moving water as have been impelled against the west coast of South America several times within the present century.

This hypothesis furthermore affords us an explanation of one of the most puzzling features in the history of sedimentary formations. It is a fact well known to geologists that in almost all the great formations there exist considerable sections of shales or deposits of clayey materials which are destitute of organic matter, although the beds above and below them contain an abundance of fossils. It seems not improbable that the frequent occurrence of earthquake shocks may serve to prevent the establishment of organic life on certain portions of the sea floor and so leave work of sedimentation altogether to the gradual down-showering of the inorganic sediments which the sea is constantly depositing on its floor.

The destruction accomplished by an earthquake shock is likely to extend over a very large area. In the greater of these disturbances the field of a whole ocean such as the Atlantic may possibly be involved. In lesser shocks the surface affected is likely to be several thousand square miles in area. The reëstablishment of organic conditions on such a desolated sea floor could not be immediately effected. In the depths of the sea where the currents are inconsiderable such a reëstablishment of organic relations might well require a period considerable even in a geological sense. We can often see evidence of this slowness of return on the part of animals and of the difficulty with which the reëstablishment is effected in the considerable thickness of the clay layer which intervenes between the limestones. There is hardly any doubt that the limestones of the Cincinnati series in the central portion of the Ohio valley were deposited at a considerable distance from shore lines which could have furnished sediments, and yet we often find shales a foot or more in thickness which were deposited between two layers of limestone. The time required for the accumulation of such a stratum in the thallassal seas is probably great; it certainly must be reckoned by thousands of years. Therefore we may presume that the impoverished condition of the life continued for a long time and that repeated shocks of great violence might retain a sea floor in the condition in which it could not be occupied by life even if the shocks came at intervals of several thousand years.

It is evident that such a disturbing agent as would prevent the possession of the sea floor by organic forms for a considerable period must have much effect upon the rate of deposition of sediment. In many of our limestone sections limy matter is more than nine-tenths of the whole contents of the strata. Thus the arrest in the development of organic forms may reduce the rate of growth of deposits to one-tenth their original amount. In this manner through the recurrence of seismic accidents in particular areas for long continued periods we may have a slow deposition of strata on one portion of the sea floor while in other regions, exempt from such disturbances, accumulation may proceed with great rapidity. It seems likely that the movements of the earth's surface are considerably affected by the rate of deposition upon the sea floor. In some manner, as yet not well explained, rapid deposition appears often to be accompanied by a subsidence of the surface on which the deposit is formed while the neighboring land area may undergo a corresponding elevation. Therefore a cause which interferes with or which fosters the development of organic life on the sea floor may have a considerable influence on the movements of the earth's crust.

It is also easy to see that the effect of such destructions on the history of organic species may be most important. Each time a region is depopulated it becomes a free field for the life which is enabled to return to it. Wherever such a free field is afforded to organic species an opportunity is given for a readjustment of relations between various forms and consequently for rapid diversification. In an old settled region, whether on sea floor or on the land, adjustments have been accomplished which tend to limit variations. In the return of life to such a region an opportunity is given for readjustment which is never afforded without the access of cataclysms which laid the area open for resettlement. Thus whether it be in reoccupying the field opened by the retreat of glaciers on the land or in repossessing an area over which life has been expelled on the sea floor, organisms find an admirable opportunity to effect variations when they work their way back into the region whence they have been driven.

It would be interesting to follow the considerations suggested in the last paragraph, but it would lead us away from our subject matter, the main point of which concerns the causes of the breaks in strata. We may sum up the propositions of this paper in the following manner. Geographic change, alterations in the level of the sea floor or in the position of shores in relation to areas of deposition account for certain important successions of deposits and in some cases may explain the interruptions in the continuity of beds. By far the larger portion of the intervals between the beds of stratified rocks, however, must be accounted for in another way. The most likely explanation of them appears to be that which is above suggested, viz.: the shocks produced in earthquake movements and the consequent disturbance of the mud on the sea floor. No other cause appears to be of so general a nature as this. Though the poisoning action of volcanic gases may effect considerable destructions of marine life, it does not seem probable that they can account for any considerable part of our stratification planes. To seismic movements it appears to me that we must look for the larger part of the horizontal divisions which characterize our sedimentary deposits.

Dr. T. Sterry Hunt and Prof. Hyatt discussed the subject.

Dr. G. L. Goodale showed some glass models made by Blatschka of Dresden, illustrating the morphology of plants.

Dr. Goodale also spoke of the discovery by Just of new respiratory organs in certain plants.

Dr. T. Sterry Hunt gave an account of his personal experience of the Sonora earthquake of last May.

Professor Shaler stated that he had been investigating the extent of earthquake action in New England since the Glacial period, and would be glad to receive information concerning the location of balanced rocks.

General Meeting, Dec. 21, 1887.

The President, Prof. F. W. Putnam, in the chair.

The President called the meeting to order and addressed the members as follows:

Members of the Society:—Ill health has prevented my being with you for the past two meetings, and I regret that on resuming this chair the sad duty again falls to me of announcing the loss of another of our corporate members, Cordelia Adelaide Studley, who died on the third of the present month, in her thirty-second year.

Miss Studley was a woman of broad culture and of a remarkable mind, but possessed of such extreme sensitiveness that it was difficult for her to meet the trials of the independent life she felt it her duty, from the highest and most honorable of motives, to follow. To these were added such true womanly attributes as to endear her to all who had the good fortune of claiming her personal friendship, while to those who knew her but slightly these lovely qualities were so marked as to make her a most attractive woman.

With the firm belief that it is the duty of every woman to have some special purpose in life, she entered upon medical studies, first at the Boston University and afterwards at Ann Arbor, where she hoped to take her degree ; but she overtasked her strength and returned to Boston for medical treatment under one of our highest specialists.

In October, 1881, she became a special student in the Peabody Museum of American Archæology and Ethnology at Cambridge, where her remarkable qualifications soon led to her appointment as an assistant, and until July, 1886, she there devoted herself to the special study of human osteology, with the hope of solving the great problem of the American races, so far as it could be solved by that study. In these investigations she made remarkable progress and the paper upon the human remains from the caves in Coahuila, Mexico, printed in the 18th Report of the Museum, in 1884, placed her at once in the front rank of craniologists and indicates how important would have been her maturer studies in that direction. Unfortunately, pecuniary reasons led her to abandon these researches and accept another position where the duties proved to be beyond her strength. She resigned this place and while hopefully awaiting restored health in order, as she hoped, to become a teacher at Hampton, she was nervously prostrated and her lamentable death soon followed.

So few women have taken an active part in scientific research in our community that it is meet for us to take particular notice of our gentle and gifted associate whose presence we shall so greatly miss at our gatherings.

The records of the last meeting were read and approved. The list of candidates for membership was read.

The President then, as a text for the discussion and papers for the evening, showed a collection of palæolithic implements from America and Europe.

The following is an abstract of his comments :—

It falls to me to open the discussions which are to follow, by calling your attention to the character of the objects known as palæolithic implements, or the weapons and tools of early man, which have been found under similar geological conditions in many portions of the world. For this purpose I have selected from the collections in the Peabody Museum of Archæology at Cambridge, a comparative series of specimens from both sides of the Atlantic.

Of the specimens before you, those from France were received at the Museum in the famous Mortillet collection and are from the gravel of the valley of the Somme, at Abbeville, where palæolithic implements were first discovered by M. Boucher de Perthes between the years 1840 and 1847, and at St. Acheul, where Dr. Rigollot next found them in 1855.

The single English specimen, brought in for comparison with American forms, was given to the Museum by Mr. John Evans of London, the author of the most thorough and important work ever written upon stone implements. This rude implement he obtained from Milford Hill, between the Avon and the Bourne, where many palæolithic implements have been found in the gravel, and were first described by Dr. Blackmore in 1865.

A large part of the American specimens on the table are from the gravels at Trenton, New Jersey, in the Delaware valley, where, in 1875, Dr. Abbott made the discovery of palæolithic implements in America. This place is of the same importance to American archæology that Abbeville is to European.

The several quartz implements from Little Falls, Minnesota, were collected by Miss Babbitt, the discoverer of palæolithic implements in the Upper Mississippi valley in 1879.

The two specimens found in the gravels of the Little Miami valley in Ohio, by Dr. Metz, the discoverer of palæolithic implements in Ohio, in 1885, are also on the table.

Thus there is now spread before you a remarkable group of authentic specimens of these implements of early man.

As they are passed about for examination, I will call your attention to a few matters of particular interest in connection with the forms which they present and the rocks of which they are made. As you probably know, the large proportion of palæolithic implements from France and England are made of nodules of flint, and that is the material of those before us from those countries. You will notice that while slight, if any, signs of use can be traced, they have a remarkable gloss over their chipped portions, which is analogous to the patina upon old bronze, and is an unquestionable sign of great age. Implements of the same character, but made of chert, quartzite, or other stones, have been found in the gravel deposits of England, and, I believe, on the continent also, but they are extremely rare.

In this country the term "flints" is applied generally to chipped implements made of chert, jasper, chalcedony, obsidian, quartz and other stones, but it is remarkable that with four exceptions all the implements known from the Trenton gravels are made of argillite, and that those from Little Falls are, without exception, made of quartz. The exceptions from Trenton are two of quartz, one of quartzite and one made from a black-chert pebble.

The first specimen found in Ohio is made from a pebble of black chert and is not only identical with the New Jersey specimen as to mineral but nearly so as to size and shape, and character of the chipping. The other specimen from Ohio is made from a hard dark pebble which has not yet been identified.

We have thus to compare implements made of several distinct minerals, which would from natural causes splinter and flake in different ways. Yet here before you, made of these several different kinds of rocks, are implements identical in shape, often agreeing in size and in minute points of structure, from both sides of the Atlantic and from distant points in America. If there are any persons present who may doubt the artificial character of the specimens, I can only say open your eyes and be convinced.

The rudest implement in the lot is the dark pebble found by Dr. Metz, twenty-five feet from the surface, in the gravel at Loveland, in the Little Miami valley, in 1886. That pieces or chips had been struck from this stone we must all admit, but that they were struck off by the hand of man we might well question had we not such a series as this now before us; where, with this rude specimen from the gravels of Ohio, we can make a close comparison with this one, of a different stone, from Le Moustier, an unquestionable implement of the early cave-men of France. A comparison of the two with this implement of argillite from Trenton (figure 418 of Dr. Abbott's Primitive Industry) and with this one of flint from the gravels of Milford Hill in England, shows how, in each successively, a few more chips have been struck from the stone until in this last, as rude as it is, there is none of the original surface of the flint remaining; while in the first from Ohio, only a portion of the surface of the pebble has been chipped or broken away, somewhat as in the specimen from St. Acheul represented by Mr. Evans on his plate II, fig. 15.

The two specimens to which I shall next call your attention were evidently designed as rude cutting implements to be held in the hand. They are remarkable for their close agreement in size and form, and outline of their slightly abraded cutting edges, yet one is of argillite from Trenton, and the other is of quartz from Little Falls.

As remarkable instances of identity in form and material, and close agreement in size, of implements from distant places, are the two well chipped pebbles of black chert; one from the gravel of Ohio and the other from that of New Jersey. The latter is figured in Dr. Abbott's volume (Primitive Industry, fig. 423). These closely resemble the ovato-lanceolate implement of flint from St. Acheul, figured by Mr. Evans (plate II, fig. 12).

Of similar interest are the two small ovate implements of white quartz, one from Trenton and the other from Little Falls. These again have their representatives among the flint implements of Great Britain, both as to size and shape, as shown by Mr. Evans' figure 452. The shoe-shaped implements (similar to fig. 429 of Mr. Evans' volume), flat upon one surface, and high at one end and chipped to the "toe" or point and over the front of the "foot," are found in Trenton chipped out of pieces of argillite. The specimen from Trenton, and the one of flint placed with it from St. Acheul, are interesting for their close resemblance in size and shape and uniformity of chipping.

Of the irregular ovate implements, like those called by Dr. Abbott "turtle backs" (fig. 444 of Primitive Industry), there are before you a specimen of argillite from Trenton (the original of Dr. Abbott's figure), and one of the same size and shape, but of flint, from St. Acheul. These two specimens, although of different size, are interesting from the fact that while they each have heavy buts, the opposite end of each is chipped to a rounded cutting edge, and they are nearly identical in form. Of a similar form is the British implement represented by Mr. Evans in his figure 418.

I will close my comparison of these implements, although it could be carried much farther with the specimens in the Peabody Museum, by calling your attention to these two large pointed implements, one of flint from the gravel of the Somme valley at St. Acheul, and the other of argillite from the gravel of the Delaware valley at Trenton. This is a form of palæolithic implement which is common to the gravels of France and England and they are generally of large size, like those before you. In both these specimens the original surface of the stone is left untouched at the large end and forms a smooth rounded portion which is perfectly adapted to be grasped and held by the hand. From this thick end the stone is regularly chipped on all sides until a long slender point is produced.

In the several instances to which I have called your attention, you can but perceive that man in this early period of his existence had learned to fashion the best available material, be it flint, argillite, quartz, chert or other rocks, into implements and weapons suitable to his requirements. You will also have noticed, during this comparison of the forms of the implements, that his requirements were about the same on both sides of the Atlantic, when he was living under conditions of climate and environment which must have been very near alike on both continents, and when such animals as the mammoth and the mastodon, with others now extinct, were his contemporaries.

Was he of one race on the two continents? Has he left descendants or has he passed out of existence with the mammoth and the mastodon? These are questions we hope may be answered in the near future.

Papers were then read by Dr. Abbott, Professor Wright and Mr. Upham.

ON THE ANTIQUITY OF MAN IN THE VALLEY OF THE DELAWARE.

BY DR. CHARLES C. ABBOTT.

Dr. Abbott began his remarks on the evidences of the Antiquity of Man in the Valley of the Delaware, and of his own more recent discoveries, by reading an abstract of a communication read, November last, by W J McGee before the Anthropological Society of Washington. In this paper the author gives the results of his examination of the surface geology of the locality in question. He states that there are two deposits of gravel covering the present valley, which are very distinct in origin, age and general character. The older and more extensive one is composed of usually small quartzite pebbles, or of fine quartzite sand, the latter frequently colored a deep reddish-brown from the abundant presence of oxide of iron. This deposit has been designated by Dr. Cook as the "southern drift," and by Professor Lewis as the "yellow gravel." Mr. McGee has proposed the name of "Columbian gravel." Overlying this, for a limited area, so that it forms the bed of the stream and lines its banks for some distance, both above and below tide-water limits, is another deposit of gravel, wholly different from the preceding, or "Columbian," in that it consists of pebbles and large boulders, with some sand. This is now well known as the Trenton gravel, being called so from the fact that its greatest deposit is at the site of the city of that name. It is an accumulation derived by water and ice-action from the terminal moraine of the second or last glacial period—the result of the floods that occurred during the melting and recession of the ice-sheet. At this time the region was so far depressed as to permit the tide to reach northward quite to the terminal moraine, some sixty miles beyond the present tide limit. This later deposit, then, is the most recent distinctly traceable phenomenon of the last glacial epoch.

It is in this accumulation of redistributed morainic material that the rudely chipped implements are found; and Mr. McGee points out that the conditions of the country, bounding the submerged area, were in all respects favorable for man's occupancy at that time.

Since the last occasion upon which the discoveries of rude or palæolithic implements from the Trenton gravel were announced to this society (1883), the various exposed sections of the deposit have been carefully examined by Dr. Abbott and several specimens of much interest have been obtained; and with these were two fragments of human crania, found at different, and both at very significant depths. No further evidence, it would now seem, was required to prove the occurrence of man on the Atlantic seaboard of North America in strictly glacial times, and yet many objections are still urged against this view.

One of these is that the so-called "implements" are too rude and indefinite in design to have been available for all of even primitive man's few wants, and yet nothing more elaborate of a different pattern is referred to the same age and origin. May not, it is asked, these "broken stones" be natural objects? The character of the fractures clearly proves that they are not. It is inconceivable that, in every case, the detached portions of a naturally broken stone should bear such relations to each other, that an effective cutting edge or penetrating point should result.

As Mr. McGee has pointed out, there was a wide tract of habitable land adjoining the area now covered by the Trenton gravels; and certainly there is no inherent improbability in the suggestion that a proportion of the ruder forms of stone implements found upon the surface of the Columbia gravel may not be properly referrible to the palæolithic folk rather than to the Indians that succeeded them. It is clearly evident that the typical palæolithic implements were weapons used in hunting, and as such would be used about the river where the greater portion of the game would be. Hunting implements would be liable to be lost; while the simple domestic implements, mostly used by the women in the preparation of food and clothing, would seldom, if ever, be carried to the river. As at present, we find a large range of objects of Indian manufacture confined to spots that give not only by their presence, but by other evidence, proof that such localities were village sites; while arrowheads and spearpoints are distributed over the whole country. So we find the single weapon of the older people in the gravels that once formed the river's bed, and very sparingly elsewhere; while equally rude objects—ordinarily classed as Indian relics—are sometimes found under conditions which strongly suggest that they were used by another and an earlier people; in other words, are contemporaneous with the objects found buried in the gravel.

There is unquestionably much to be done before every objection, that may fairly be urged, is met and answered; but the results so far obtained all point in the one direction, that of the existence of man in the Delaware Valley, when the "Trenton gravels" were being deposited.

ON THE AGE OF THE OHIO GRAVEL-BEDS.

BY REV. G. FREDERICK WRIGHT.

In November, 1880, I visited Trenton, New Jersey, in company with Professor Boyd Dawkins, Professor Henry W. Haynes, and Professor H. Carvill Lewis. Under the guidance of Dr. Abbott we visited all the sections of the Trenton gravel that were then exposed in fresh railroad cuttings and in embankments which had been recently undermined. Though not finding any palæolithic implements myself, several were found by Professors Haynes and Dawkins in piles of gravel where my inexperienced eye had only retained impressions of glaciated pebbles. One of the palæoliths found at that time is exhibited this evening by Professor Haynes; and both he and Professor Dawkins were satisfied that some of the implements they found must have lain in undisturbed deposits of the gravel, though they were actually found in the talus which had recently accumulated at the foot of the various cuttings of the bank. I have subsequently revisited the locality two or three times so as to increase my familiarity with the situation and character of the gravel deposits.

Shortly before our visit to Trenton the true glacial character of the gravel in which Dr. Abbott had found the palæolithic implements had been pointed out by Professor Cook, of the New Jersey Geological Survey. (See his report for 1878, p. 22, and Clay Report, 1878, p. 17.) It was at this time, and with these facts before us, that Professor Lewis and myself laid the extensive plans for the exploration of the southern boundary of the glaciated region to which I have since given unremitting attention during the leisure afforded from my regular duties.[1]

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[1] Detailed results of my own work may be found in the joint report of Professor Lewis and myself in 1884 upon the Terminal Moraine of Pennsylvania (constituting volume Z in the Reports of the Second Geological Survey) and in my report upon The Glacial Boundary in Ohio, Indiana, and Kentucky (made to the Western Reserve Historical Society, Cleveland, Ohio, in 1884). My report upon the glacial boundary in Illinois, and of subsequent investigations in the Ohio valley, has not yet appeared, but will be published soon in a monograph on the whole subject prepared for the United States Geological Survey. Some additional facts may also be found in my chapter on the Glacial Boundary in Ohio, in volume v, of the Ohio Geological Survey, pp. 750–772, and in articles in the American Journal of Science, vol. XXVI (July, 1882), in the American Naturalist for August, 1884, in the Bibliotheca Sacra for April, 1884, and in the Ohio Archæological and Historical Quarterly for September and December, 1887; also in the report of the Meeting of this Society for Jan. 19, 1881 (vol. XXI, pp. 137–145); while a general discussion of the whole situation may be found in Chapter VI, of my volume entitled "Studies in Science and Religion."

The accompanying cut (Fig. 1) shows the relation of the palæolithic-bearing gravel at Trenton to the glacial period. The ice surmounted the Catskills, and extended down the valley of the Delaware River to Belvidere, a few miles above Easton. Here, as elsewhere, on all the streams which rise within the glaciated area

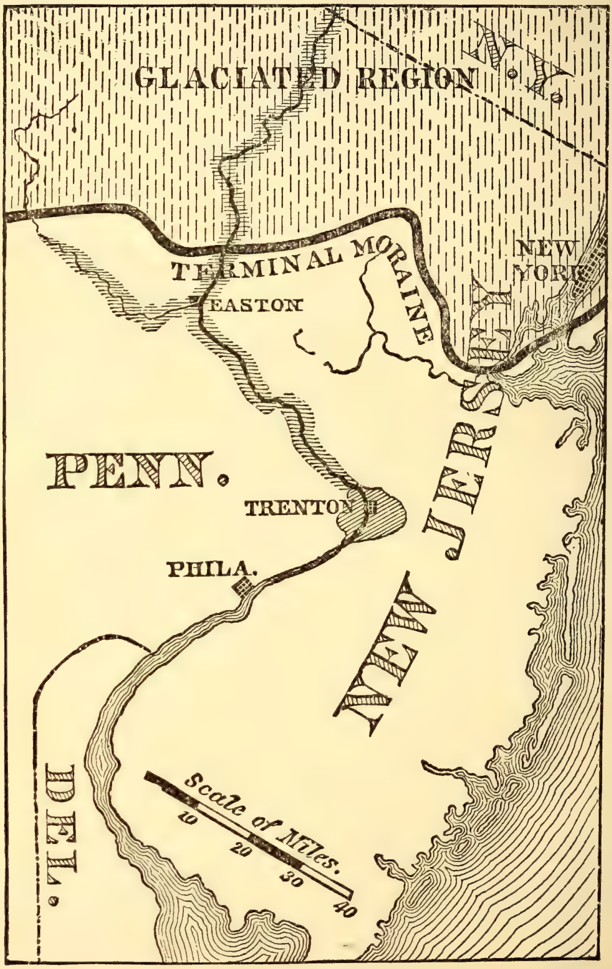
GLACIATED REGION
N. Y.
TERMINAL MORAINE
NEW YORK
EASTON
PENN.
TRENTON
PHILA.
NEW JERSEY
DEL.
Scale of Miles.
10
20
30
40

FIG. 1 (taken from Studies in Science and Religion). Shows, in addition to the glaciated area of New Jersey, the glacial terraces of gravel along the Lehigh and Delaware rivers, and also the delta-terrace at Trenton, from which Dr. C. C. Abbott has taken palæolithic implements.

and flow southward, extensive terraces of what are now called overwash gravels line the valley on either side down to tide-water, which is reached at Trenton. These terraces in the upper part of the valley are from twenty to forty feet above the present high-water mark. The valley descends through the most of its

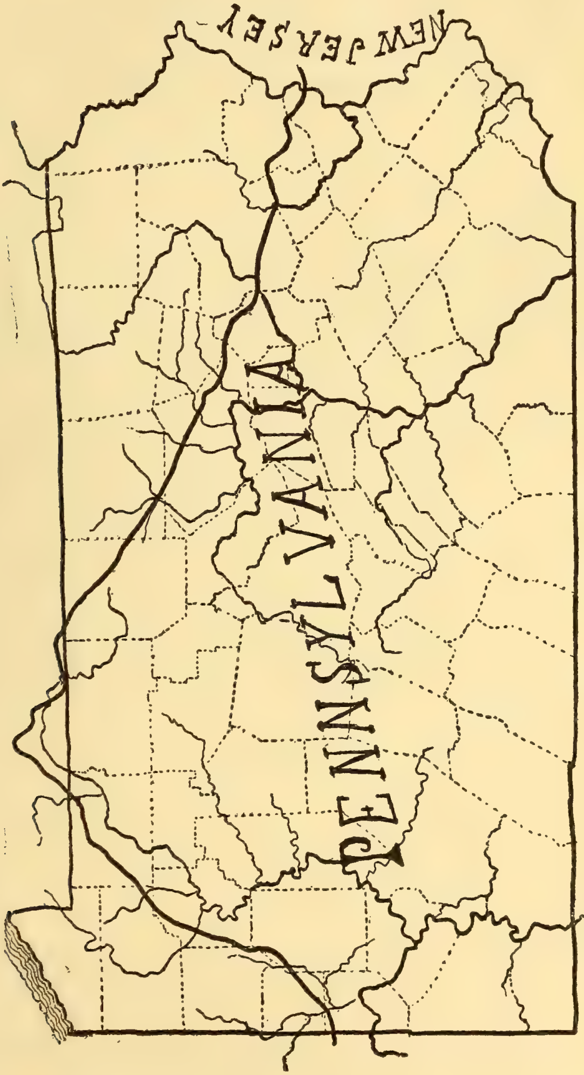

FIG. 2. The broad black line shows the southern boundary of the glaciated area of Pennsylvania and its relation to the drainage systems of the region.

course at the rate of two or three feet a mile, and is narrow. But at Trenton it suddenly enlarges, and comes down to the level of the tide. Here a wide and extensive delta-terrace is deposited, being about three miles in diameter. The surface of this delta-deposit is about fifty feet above tide and has a clearly defined margin all around, being composed of material derived from the valley above, and such as characterizes the glacial terraces lining the valley up to and beyond the terminal moraine; in short, it is a deposit of the overwash gravels laid down during the periodical floods incident to the presence of glacial ice in the upper portions of the drainage basin of the river.

Since my first visit to Trenton I have studied attentively all the streams situated like the Delaware with reference to the glaciated area between the Atlantic Ocean and the Mississippi River, and can state from personal observation, as partially recorded in the publications referred to, that a common cause, which cannot be anything else than glacial floods operating while the ice remained over the headwaters of these streams, has been at work making gravel deposits similar to those described along the Delaware. The accompanying cuts (see Figs. 2 and 3) show the relation of the various streams in Pennsylvania and Ohio to the continental ice-sheet while its front continued on the southern watershed of the continent. Without exception, those southerly flowing streams, whose drainage area lies to any considerable extent within the glaciated regions, are lined by extensive terraces of the overwash gravel of the glacial period.

On obtaining definite information as to these facts, I at once pointed out in my article in the American Journal of Science, vol. xxvi, pp. 7–14, as well as in my report to the Western Reserve Historical Society, pp. 26–27, and in the Ohio Archæological and Historical Quarterly, vol. i, pp. 176–177, the importance of having local observers turn their attention to the discovery of palæoliths at various points in Ohio, where the glacial conditions were similar to those in the valley of the Delaware at Trenton, N. J. The language in my report to the Western Historical Society (p. 26) is as follows: "The gravel in which they [Dr. Abbott's implements] are found is glacial gravel deposited upon the banks of the Delaware when, during the last stages of the glacial period, the river was swollen with vast floods of water from the melting ice. Man was on this continent at that period when the climate and ice of Greenland extended to the mouth of New York harbor. The probability is that if he was in New Jersey at that time he was also upon the banks of the Ohio, and the extensive terrace and gravel deposits in the southern part of our state should be closely scanned by archæologists. When observers become familiar with the rude form of these palæolithic implements they will doubtless find them in abundance. But whether we find them or not in this state [Ohio],

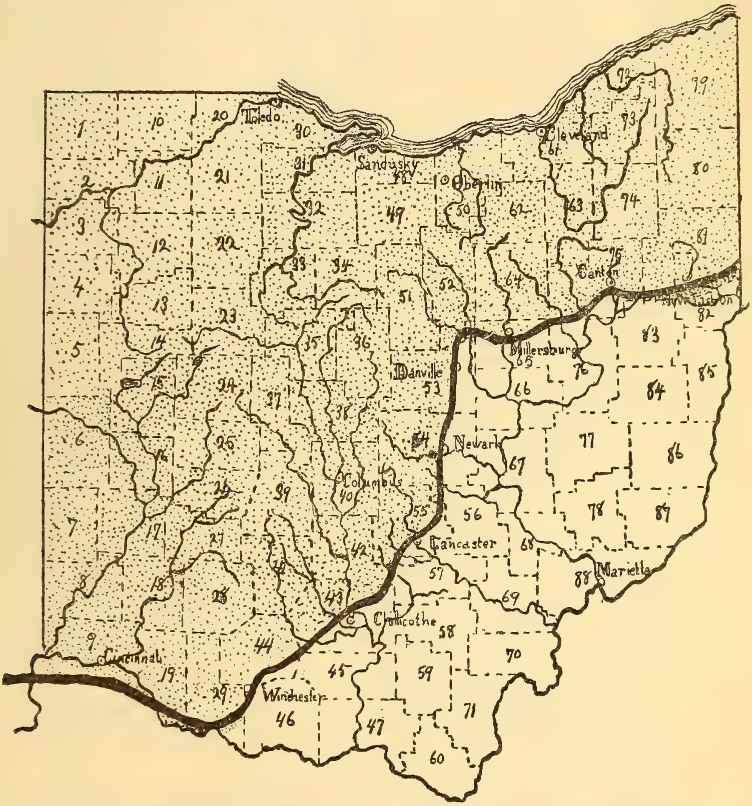
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FIG. 3. The dotted surface shows the Glaciated area of Ohio. Hamilton county, bounded on the east by the Little Miami River, where Dr. Metz has found palæolithic implements, is indicated by the figure, 9.

if you admit, as I am compelled to do, the genuineness of those found by Dr. Abbott, our investigations into the glacial phenomena of Ohio must have an important archæological significance, for they bear upon the question of the chronology of the glacial period, and so upon that of man's appearance in New Jersey."

The substance of these remarks had been previously made by me in a meeting of this Society for March 7, 1883, and reported in Science, vol. I, pp. 269–271. Commenting upon this report, Dr. Abbott sent a communication to *Science* from which the following extracts are very significant and interesting as connected with our discussion this evening (see Science, vol. I, p. 359):—

"In *Science* of April 13, p. 271, Professor Wright remarks that 'no palæolithic implements have as yet been found [in Ohio], but they may be confidently looked for.' It has seemed to me possible, from my own studies of the remains of palæolithic man in the valley of the Delaware River, that traces of his presence may only be found in those river-valleys which lead directly to the Atlantic coast, and that palæolithic man was essentially a coast-ranger, and not a dweller in the interior of the continent. If we associate these early people with the seal and walrus rather than with the reindeer, and consider them essentially hunters of these amphibious mammals rather than of the latter, it is not incredible, I submit, that they did not wander so far inland as Ohio, nor even so far as the eastern slope of the Alleghanies; and we need not be surprised if palæolithic implements, concerning which there can be no doubt whatever,—for recent Indians made and used stone implements that are 'palæolithic' in character,—are not found in Ohio, nor even in Pennsylvania west of the valley of the Susquehanna River."

"On the other hand, if the relationship of palæolithic man and the Eskimo is not problematical, and the latter is of American origin, then I submit that man was preglacial in America, was driven southward by the extension of the ice-sheet, and probably voluntarily retreated with it to more northern regions; and, if so, then in Ohio true palæolithic implements will surely be found, and evidences of man's preglacial age will ultimately be found in the once glaciated areas of our continent."

The expectation of finding evidence of preglacial man in Ohio has at length been met.

At the meeting of this Society[1] for November 4, 1885, "Mr. Putnam showed an implement chipped from a pebble of black flint, found by Dr. C. L. Metz in gravel, eight feet below the surface, in Madisonville, Ohio. This rude implement is about the same size and shape of one made of the same material, found by Dr. Abbott in the Trenton, N. J., gravel, and is of special interest as the first one known from the gravels of Ohio." Professor Putnam's announcement, followed by a letter from Dr. Metz, saying that he had since found another implement in the gravel at Loveland, led me, on the 11th and 12th of November, to visit the localities and see their relation to the glacial deposits of the region. The results I here detail.

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[1] See Proc. Bost. Soc. Nat. Hist., vol. XXIII, p. 242.

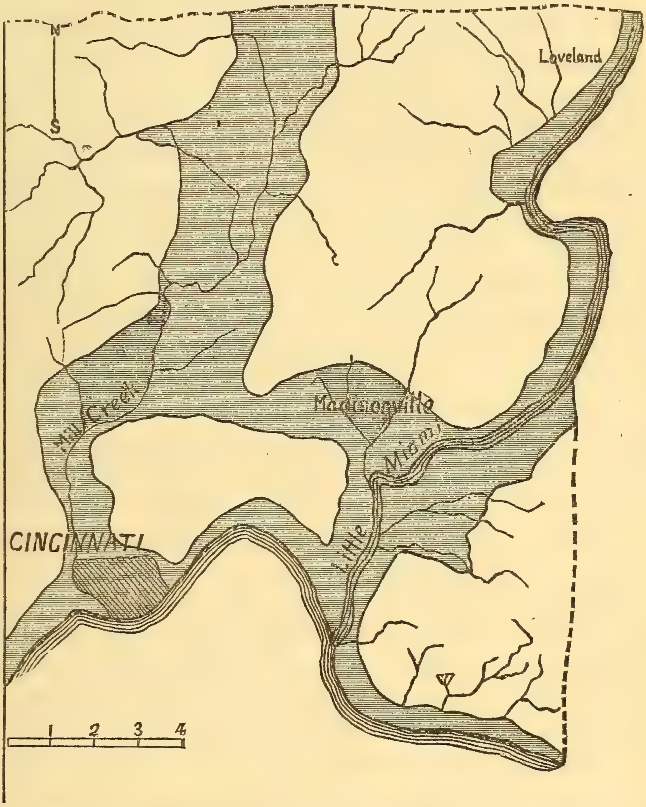

FIG. 4. Map of the eastern portion of Hamilton county, Ohio. The space covered by horizontal lines is occupied by preglacial valleys, filled to a height of 100 to 200 feet above the Ohio River with modified drift. The unlined portion consists of the table-land from 200 to 500 feet above the river.

Madisonville is situated eleven miles northeast of Cincinnati, in a singular depression connecting the Little Miami River with Mill Creek, about five miles back from the Ohio (see Fig. 4). The Little

Miami joins the Ohio some miles above Cincinnati, while Mill Creek joins it just below the city. The general height of the hills in that vicinity above the river is from 400 to 500 feet. But the hills just north of Cincinnati are separated from the general elevation farther back by the depression referred to, in which Madisonville is situated.

The depression is from one to two miles wide, and about five miles long, from one stream to the other, and is occupied by a deposit of gravel, sand and loam, clearly enough belonging to the glacial-terrace epoch. The surface of this is generally level, and is about 200 feet above the low-water mark in the Ohio. On the east side, on the Little Miami River, at Red Bank, the gravel is rather coarse, ranging from one to three or four inches, interstratified with sand, and underlain, near the river-level, with fine clay. There is here a thin covering of loess, or fine loam. On going westward this loess deposit increases in thickness, being at Madisonville, one mile west, about eight feet thick. Farther west it is much deeper, and seems to take the place of the gravel entirely. At several railroad cuttings, the compact glacial clay, technically called "till," with scratched stones, appears underneath all.

From this description it appears that this cross-valley, connecting Mill Creek with the Little Miami back of Avondale, Walnut Hills and the observatory, was once much deeper than now, and has been filled in with deposits made when immense glacial floods were pouring down these two streams from the north. The Little Miami was a very important line of glacial drainage, as is shown by the extensive gravel terraces all along its course, to which the railroads resort for ballast. The coarser material was deposited near the direct line of drainage, where the current was strong, while back from the river towards Madisonville, there is an increase of the fine deposit, or loess, which is practically a still-water formation.

In making an excavation for a cistern, Dr. Metz penetrated the loess just described eight feet before reaching the gravel, and there, just below the surface of the gravel, the implement referred to was found. There is no chance for it to have been covered by any slide, for the plain is extensive and level topped, and there had evidently been no previous disturbance of the gravel.

Subsequently, in the spring of the present year (1887), Dr. Metz found another palæolith in an excavation in a similar deposit in the northeast corner of the county, on the Little Miami across from Loveland. The river makes something of an elbow here, open to the west. This space is occupied by a gravel terrace about fifty feet above the stream. The terrace is composed in places of very coarse material, resembling very much that of Trenton, N. J., where Dr. Abbott has found implements. The excavation is about one-quarter of a mile back from the river, near the residence of Judge Johnson. The section shows much coarser material near the surface than at the bottom. The material is largely of the limestones of the region, with perhaps ten per cent of granitic pebbles. The limestone pebbles are partially rounded, but are largely oblong. Some of them are from one to three feet in length. These abound for the upper twenty feet of the section on the east side toward the river. One granitic boulder was about two feet in diameter. On the west side of the cut, away from the river, mastodon bones were found, a year or two ago, in a deposit of sand underlying the coarser gravel and pebbles. It was here, about thirty feet below the surface, that Dr. Metz found the palæolithic implement referred to.

In the light of the exposition just given, these implements will at once be recognized as among the most important archæological discoveries yet made in America, ranking on a par with those of Dr. Abbott, at Trenton, N. J. They show that in Ohio, as well as on the Atlantic coast, man was an inhabitant before the close of the glacial period. We can henceforth speak with confidence of interglacial man in Ohio. It is facts like these which give archæological significance to the present fruitful inquiries concerning the date of the glacial epoch in North America. When the age of the mound builders of Ohio is reckoned by centuries, that of the glacial man who chipped these palæolithic implements must be reckoned by thousands of years.

A word may properly be said with reference to the bearing of these facts upon the date of man's appearance in America. In the first place, it should be observed that, to say man was here before the close of the glacial period only fixes a minimum point as to his antiquity. How long he may have been here previous to that time must be determined by other considerations. Secondly, with our present knowledge of glacial phenomena, the date of the close of the glacial period is regarded as much more modern than it was a few years ago. Sir Charles Lyell's estimate of 35,000 years as the age of the Niagara gorge, which is one of the best measures of postglacial time which has yet been studied, is greatly reduced by what we now know of the rate at which erosion is proceeding at the falls. Ten thousand years is now regarded as a liberal allowance for the age of that gorge. But, finally, the term "close of the glacial period" is itself a very indefinite expression. The glacial period was a long time in closing. The erosion of the Niagara gorge began at a time long subsequent to the deposit of the gravel at Trenton and at Madisonville. Between those two events time enough must have elapsed for the ice-front to have receded a hundred miles or more, or all the distance from New York to Albany; since only at that stage of retreat would the valley of the Mohawk have been freed from ice so as to allow the Niagara River to begin its work. The deposits at Trenton and Madisonville took place while the ice-sheet still lingered in the southern watershed of New York, Pennsylvania and Ohio.

THE RECESSION OF THE ICE-SHEET IN MINNESOTA IN ITS RELATION TO THE GRAVEL DEPOSITS OVERLYING THE QUARTZ IMPLEMENTS FOUND BY MISS BABBITT AT LITTLE FALLS, MINN.

BY WARREN UPHAM.

How far back in geologic time can the existence of man be traced? Answers to this inquiry come from various parts of Europe and North America, bearing testimony of man's great antiquity as measured by years, though recent in contrast with the long record of geology. The observations on this subject gathered in Great Britain, France, Germany and other countries of Europe, extend the human period with certainty back to the time when confluent ice-sheets covered Ireland, Scotland, and the northern borders of England, the whole of Scandinavia, northern Germany and northwestern Russia. Within this Ice Age, the latest in the series of geologic ages preceding the present, are found evidences of man's appearance in Europe. His rudely chipped stone implements occur there in caverns and in beds of fluvial gravel and sand high above the present river-courses, associated with bones of the reindeer and other Arctic animals, which the ice-fields had driven far southward of their present geographic limits. Both in Europe and America the great Ice Age appears to have comprised two principal glacial epochs when severe cold and plentiful snowfall caused vast ice-sheets to be accumulated upon the land, separated by a warmer interglacial epoch when the ice retreated, or was perhaps wholly melted away. These early vestiges of man in Europe are therefore referable to the interglacial epoch and to the second time of glaciation.

In the United States similar stone implements of early man are found near Trenton in New Jersey, in southern Ohio, and in central Minnesota, occurring in beds of gravel and sand, which are evidently modified drift derived from the receding ice-sheet of the last epoch of glaciation and deposited by the rivers that were produced in its final melting. During the last great rise of the quaternary lake Lahontan, in western Nevada, referable to the same late part of the glacial period, man hunted on its shores and was provided with spearheads of chipped obsidian[1]. Relics of man are also described from various placer gravels of California,[2] showing at least that he existed there contemporaneously with the foregoing, and probably even in a much earlier portion of the glacial period, near its beginning.[3]

The purpose of this paper is to describe the geologic situation and relationship of the gravel and sand deposits at Little Falls, Minnesota, in which Miss Franc E. Babbitt, several years ago, found implements and fragments of chipped quartz. After noting the character of the stratum where these remains of man's work occur, and of the underlying and overlying beds, their probable method of deposition will be indicated, and their place in the sequence of events constituting the history of the Ice Age will be shown. The recession of the ice-sheet of the last glacial epoch in Minnesota, to which this will direct our attention, seems to be clearly marked by as many as ten stages of halt or re-advance, in which distinct marginal moraines were accumulated, besides the moraine on the limits of its farthest extent. Six summers of geologic field-work in that state have been spent by the writer chiefly in the examination of its glacial and modified drift, of these moraines, and of the beaches and deltas of the glacial lake Agassiz, which was formed in the valley of the Red river of the north and of lake Winnipeg by the barrier of the departing ice-sheet. In their bearings upon this subject, my observation and study of that region convince me that the rude implements and fragments of quartz discovered at Little Falls were overspread by the glacial flood-plain of the Mississippi river, while most of the northern half of Minnesota was still covered by the ice, contemporaneously with its formation of the massive moraines of the Leaf hills and with the expansion of lake Agassiz on their west side, respectively 60 and 85 miles west of Little Falls. This was during the highest stage of lake Agassiz, and previous to its extension beyond the north line of Minnesota and Dakota. More than twenty lower beaches of this glacial lake have been traced, belonging to later stages in the recession of the ice-sheet, before it was melted so far as to reduce lake Agassiz to its present representative, lake Winnipeg. Estimated by comparison with the series of moraines and beaches formed during the glacial recession, the date of the gravel plain at Little Falls appears to be about midway between the time of maximum extent of the last ice-sheet and the time of its melting on the district across which the Nelson river flows to Hudson bay.

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[1] See figure of implement in Monograph XI, U. S. Geol. Survey, p. 247. Pages 261, 263 and 269–270 of this volume show that this spearhead was lost in the lake sediments, during the second epoch of glaciation, to which also the implements in New Jersey, Ohio and Minnesota, are referable.

[2] The many occurrences of man's implements, stone mortars, etc., in the placers of California, as stated in Professor Whitney's report on the Auriferous Gravels, substantiate the history of the famous Calaveras skull, which is also there discussed. The great amount of erosion in California since the lava-flows indicates a very early time for that gravel of the old river-beds covered by lava.

[3] Professor Le Conte says, "These Drift-gravels probably represent the beginning of the Glacial epoch, though Whitney thinks an earlier or Pliocene epoch." *Elements of Geology*, revised edition, p. 555.

The town of Little Falls is on the east bank of the Mississippi river, in Morrison county, near the geographic centre of Minnesota. It is about a hundred miles northwest from Saint Paul and Minneapolis, and nearly an equal distance southeast from Itasca lake. The elevation of Itasca lake is about 1450 feet above the sea; of the Mississippi, at the head of the rapids, or Little Falls, from which the town derives its name, 1090 feet; and at the head of Saint Anthony's Falls in Minneapolis, 796 feet. Following the general course of the river, without regarding its minor bends, its descent from lake Itasca by Little Falls to Minneapolis averages about two feet per mile, and is approximately uniform along the entire distance. Considered in a broad view, this central part of the state may be described as a low plateau, elevated a few hundred feet above lake Superior on the east and the Red river valley on the west. In most portions it is only slightly undulating or rolling, but these smooth tracts alternate with belts of knolly and hilly drift, the recessional moraines of the ice-sheet, which commonly rise 50 to 100 feet, and in the Leaf Hills 100 to 350 feet, above the adjoining country. The bed-rocks are nearly everywhere concealed by the drift-deposits, into which the streams have not eroded deep valleys, their work of this kind being mostly limited to the removal of part of their glacial flood-plains. The upper portions of the Mississippi and of its chief tributaries, and all the smaller streams throughout this region, flow in many places through lakes which they have not yet filled with silt nor drained by cutting down their outlets. At Little Falls the glacial flood-plain of the Mississippi is about three miles wide, reaching two miles east, and one mile west from the river. Its elevation is 25 to 30 feet above the river at the head of the rapids, which have a descent of seven feet. The Mississippi here flows over an outcrop of Huronian slate, and the same formation is also exposed by the Little Elk river near its mouth, on the west side of the Mississippi three miles north of Little Falls. Veins of white quartz occur in the slate at both these localities, and were doubtless the source of that used by man here in the glacial period for the manufacture of his quartz implements.

The locality and section of the modified drift, where these worked fragments of quartz were found by Miss Babbitt, and the account of their discovery, are best told in her own words from her paper read before the anthropological section of the American Association for the Advancement of Science at its Minneapolis meeting in 1883. I quote as follows:

> "Rudely worked quartzes had previously been discovered here by the state geologist of Minnesota, Prof. N. H. Winchell, by whom they had been described and figured in the state geological report for 1877. . . . . The find reported by Prof. Winchell consists of chipped objects of a class generally ascribed to what is called the rude stone age. Of these many appear to be mere refuse, while others are regarded as finished and unfinished implements. The Winchell specimens have been assigned, upon geological ground, to a prehistoric era antedating that of the mound-building races, and reaching back to a time when the drift material of the terrace-plain was just receiving its final superficial deposit. It is

found that, at intervals, the surface soil of the terrace contains these quartzes to a depth of, not unfrequently, three or four feet.

"The lowest and newest formation at this place is the present flood-plain of the river. It is still in process of deposition, being yet subject to partial overflows at periods of exceptionally high water. In that portion of the town of Little Falls situated east of the Mississippi, this bottom-land is limited on the east by a high ancient river-terrace, which has here an average elevation of about 25 feet above the river. . . . . . This older terrace, like the present flood-plain, has been spread out by the immediate action of water. . . . . While occupied in examining the river bank at Little Falls in quest of wrought quartzes, one day during the season of 1879, I had occasion to ascend a slope lying between the new flood-plain and the older terrace, by a path leading through a sort of gap or notch in the latter (310 rods, very nearly, or almost one mile north of the east-west road by Vasaly's hotel; 10 rods west of the road to Belle Prairie; and 38 rods from the river). . . . . It seemed that at some past period a cut had been effected here by drainage, and that the washout thus formed had afterward been deepened by being used now and then as a wagon track. In this notch I discovered the soil to be thickly strewn with pieces of sharp, opaque quartz. These were commonly of a white color, and ranged in size from minute fragments to bits as large as a man's hand, and in some instances even larger. There were many hundreds of these chips visible, scattered over an area the width of the wagon road, and ten or fifteen yards in length. They were conspicuously unwaterworn, and likewise mostly unweathered, though occasionally a bit was picked up having some one of its surfaces weathered, while fractured or wrought faces, appearing upon other parts of it, looked as fresh as if the work of yesterday. On the other hand, the mass of stone rubbish upon and among which the quartzes were strewn is much waterworn, many of the pieces being well rounded, while none of them are wholly angular.

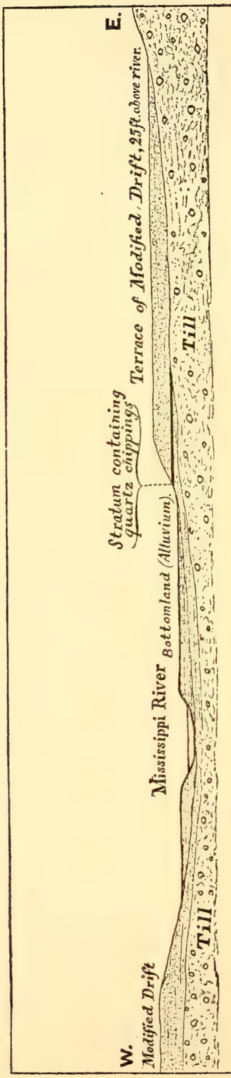
"By continued observations at this locality, I found that many of these quartz chips were brought to light at every succeeding freshet of the season, being washed out of the sand by descending drainage. Their immense and continually increasing numbers seemed to warrant the belief that they had resulted from systematic operations of some sort, once conducted, for unknown purposes, upon this particular spot. A portion of the studied specimens subsequently yielded evidence of having received shape from human hands, and therefore it was assumed provisionally that the site of exposure represented a prehistoric workshop.

"Prolonged investigation ensued; and investigation established the hitherto unsuspected fact that no quartz chips nor fragments were enclosed in the upper part of the gravel and sand terrace at the notch, nor within a considerable distance at either hand, though they were sought with careful scrutiny. . . . Ultimately it was ascertained that the notch quartzes had dropped to the level at which they were seen from a thin layer of them once lying from ten inches to two feet above it, and subsequently broken up through the wearing away of the sand underneath by drainage. This layer or stratum was still intact on the north and south and partially so on the east, in which direction it had, however, at certain points, suffered some displacement by wagoning. It extended in a nearly horizontal plane into the terrace, in the sloping edge of which the notch, opening into its west bank and truncated at its edge, is cut. . . . The quartz-bearing layer averaged a few inches only in thickness, varying a little as the included pieces happened to be of smaller or larger size. The contents were commonly closely compacted, so much so that one might sometimes extract hundreds of fragments, many of them very small ones, of course, from an area of considerably less than a square yard.

"The quartz bed, so far as examined, rested upon a few inches of sandy soil, which passed downward into a coarse waterworn gravel, immediately overlying till. Above the quartz chips, stratified gravel and sand extended up to the surface of the terrace. The pebbles of the gravel lying directly on the quartz-bearing stratum were small and well rounded, and were noticeably less angular than those of the gravel below. The stratum of quartz chips lay at a level some twelve or fifteen feet lower than the plane of the terrace-top.

"These observations show that the quartz chips were spread originally upon an ancient surface that has been since covered deeply by the modified drift which forms the terrace. It will be remembered that the quartz chips and implements discovered by Prof. Winchell in this vicinity are contained in the upper stratum of the terrace-plain; but the notch quartzes do not occur at the terrace-top, and cannot have been derived from it, but are confined strictly to a single stratum of the lower gravels closely overlying the till. Hence the two sets of objects cannot be synchronous, though they may have been produced by the same race at different stages of its existence. The notch quartzes must, of course, be older than those described by Prof. Winchell, by at least the lapse of time required for the deposition of the twelve or fifteen feet of modified drift forming the upper part of the terrace-plain, above the quartz-bearing stratum."

This description by Miss Babbitt shows that these implements and fragments of chipped quartz occurred in a well defined thin layer in the modified drift forming the glacial flood-plain of the Mississippi river, as shown in the section which I have drawn (see the following figure). I have examined the terraces and plains of this valley drift from St. Paul and Minneapolis to Brainerd, some twenty-five miles north of Little Falls, and find them similar in material and origin with the modified drift terraces in the valleys of the Merrimac, Connecticut and other rivers in New England. These water-courses extending southward from the region that was covered by the ice-sheet became the avenues of drainage from it during its retreat. A part of the drift which had been contained in the lower portion of the ice was then washed away by the streams formed on the ice in its rapid melting and was deposited as modified drift,


W.
E.
Modified Drift
Till
Mississippi River
Bottomland (Alluvium)
Stratum containing quartz chippings
Till
Terrace of Modified Drift, 25 ft. above river.

SECTION ACROSS THE MISSISSIPPI VALLEY AT LITTLE FALLS, MINNESOTA, showing the stratum in which chipped quartz fragments were found by Miss Franc E Babbitt, as described in Proc. of A.A.A.S., Vol. xxxii, pp. 385–390.

forming layers of gravel, sand and fine silt, in the valleys along which the floods supplied by this melting descended toward the ocean. Along the Mississippi the flood-plain of modified drift at Brainerd has a height of about 60 feet above the river; at Little Falls, as before noted, its height is 25 to 30 feet; at Saint Cloud, 60 feet; at Clearwater and Monticello, 70 to 80 feet; at Dayton, 45 feet; and at Minneapolis, 25 to 30 feet above the river at the head of Saint Anthony's Falls.

The modified drift at Little Falls lies on the till or direct deposit of the ice-sheet, and forms a surface over which the ice never re-advanced. It lies far within the area that was ice-covered in the second and latest principal epoch of glaciation, and by reviewing the steps in the recession of the ice of that epoch we shall be able to ascertain approximately what were the outlines of its receding margin when the gravel and sand plain of Little Falls was deposited, enclosing these evidences of man's presence. The ice-sheet, supplying both this modified drift and the floods by which it was brought, still covered much of the upper part of the Mississippi basin, which only reaches about a hundred miles north of Little Falls; and the courses of massive morainic belts show the continuation of the glacial boundary northwestward across Dakota and with less clearness eastward across the Laurentian lakes.

When the latest North American ice-sheet attained its greatest area, its southern portion from lake Erie to Dakota consisted of vast lobes, one of which reached from central and western Minnesota south to central Iowa. This lobe in its maximum extent ended near Des Moines, and its margin was marked by the Altamont moraine, the first and outermost in the series of eleven distinct marginal moraines of this epoch which are recognizable in Minnesota. When the second or Gary moraine was formed, it terminated on the south at Mineral ridge in Boone county, Iowa. At the time of the third or Antelope moraine, it had farther retreated to Forest City and Pilot mound in Hancock county, Iowa. The fourth or Kiester moraine was formed when the southern extremity of the ice-lobe had retreated across the south line of Minnesota and halted a few miles from it in Freeborn and Faribault counties. The fifth or Elysian moraine, crossing southern Le Sueur county, Minnesota, marks the next halting-place of the ice. At the time of formation of the fifth moraine, the south end of the ice-lobe had been melted back a hundred and eighty miles from its farthest extent, and its southwest side, which at first rested on the crest of the Coteau des Prairies, had retired thirty to fifty miles to the east side of Big Stone lake and the east part of Yellow Medicine county. During its next stage of retreat this ice-lobe was melted away from the whole of Le Sueur county, and its southeast extremity was withdrawn to Waconia, in Carver county, where it again halted, forming its sixth or Waconia moraine. The seventh or Dovre moraine marks a pause in its recession when its southeast end rested on Kandiyohi county. Probably nearly all of the southern half of Minnesota was at this time divested of its ice-mantle, while nearly all of the northern half was still ice-covered, the glacial boundary across the state passing in an approximately east to west course not far from Little Falls.

By its next recessions the ice-border was withdrawn to the eighth or Fergus Falls moraine, and the ninth or Leaf Hills moraine. These are merged together in the prominent accumulations of the Leaf Hills, which reach in a semicircle from Fergus Falls to the southeast, east and northeast, a distance of fifty miles, marking the southern limits of this ice-lobe when it terminated nearly due west of Little Falls and half-way between the south and north borders of Minnesota. Conspicuous morainic hills a few miles east of Little Falls, and others in the north part of Morrison county and along its west side, seem to be correlated with the Fergus Falls moraine. Much of the modified drift of the Mississippi valley at Little Falls was probably deposited when the ice-sheet terminated at these hills five to fifteen miles distant on the east, north and west. Eastward from Morrison county, this moraine continues northeast to the north side of Mille Lacs, thence probably through the south edge of Aitkin county and the north part of Pine county, and onward northeasterly to the west end of lake Superior. The Leaf Hills moraine extends from the northeast part of the Leaf Hills, near the Leaf lakes, east across northern Todd county and northwestern Morrison county, and then north-northeast by Gull, Pelican, White Fish and Crooked lakes. Next it probably takes an eastward course, crossing the Mississippi several miles north of Sandy lake and the Saint Louis river near the mouth of the Cloquet, and thence an east-northeast course, passing not far south of the Cloquet river and reaching the north shore of lake Superior about half-way between Duluth and Pigeon point. The upper portion of the modified drift at Little Falls, probably including the stratum of chipped fragments of quartz, is referable to the time of the recession of the ice-sheet north from the Fergus Falls moraine to the Leaf Hills moraine. At the west end of the Leaf Hills and thence through a distance of fifty miles northward, this stage of recession carried the ice-border back only five to ten miles; and in the main Leaf Hills, as before noted, the two moraines are united. Across the Mississippi basin the glacial recession between them uncovered an area mainly twenty to forty miles wide. The portion of the ice-sheet nearest to Little Falls at the time of the Leaf Hills moraine was in the vicinity of Fish Trap lake and lake Alexander, in northwestern Morrison county, only twenty miles distant. There, as in the Leaf Hills, this moraine and that of Fergus Falls come together. Ascending the Mississippi, a distance of eighty miles intervened between Little Falls and the ice-border at the time of the Leaf Hills moraine, which extends approximately parallel with the river and ten to twenty miles from it on its northwest side in passing north-northeastward from Morrison county.

During the formation of the tenth or Itasca moraine, and of the eleventh or Mesabi moraine, crossing the lake region at the head of the Mississippi, the gravel and sand of the modified drift were probably wholly deposited north of Little Falls. Later moraines, formed at times of halt or re-advance, interrupting the recession of the ice-sheet between northern Minnesota and Hudson bay, have not been determined, but I believe that they exist and await discovery when the glacial drift of that wooded and very scantily inhabited region shall be fully explored. The many beaches of lake Agassiz, all showing an ascent northward when compared with the level of the present time, but with this ascent gradually decreased during the successive stages of the lake, probably find their explanation in the manner of retreat of the ice in Canada, interrupted there, as farther south, by pauses and the formation of moraines.

Contemporaneously with the deposition of the glacial flood-plain at Little Falls and the accumulation of the Leaf Hills, the ice-front forming the north shore of lake Agassiz crossed the Red river valley between Fargo and Grand Forks, and extended northwesterly across northern Dakota, as shown by its moraines remarkably developed along the south side of Devil's lake and onward to Turtle mountain. Toward the east, the ice-sheet at this time had receded from the southwest part of lake Superior, which was held about 500 feet higher than now and overflowed to the Saint Croix and Mississippi rivers by the way of the Bois Brulé river and Upper Saint Croix lake. It seems nearly certain also that the ice-border continued across Green bay and the north part of lake Michigan; and farther east I think that it probably crossed southwestern Ontario and the central or northern portions of New York, Vermont, New Hampshire and Maine. The Laurentian lakes were dammed by the retreating glacial barrier and overflowed at the lowest points on their southern watershed. The time when the Little Falls stone implements and fragments from their manufacture were covered by the modified drift seems therefore somewhat later than that of the implements found in southern Ohio and in New Jersey; for, if this was the course of the ice-boundary east from the Leaf Hills of Minnesota, it had already receded beyond the region where the glacial floods could be discharged by the Little Miami and Delaware rivers.

If the question be asked, how many thousand years ago was this, a reply is furnished by the computations of Prof. N. H. Winchell, that approximately 8,000 years have elapsed during the erosion of the postglacial gorge of the Mississippi from Fort Snelling to the falls of Saint Anthony; of Dr. Andrews, that the erosion of the shores of lake Michigan, and the resulting accumulation of dune sand drifted to the southern end of that lake, cannot have occupied more than 7,500 years; of Professor Wright, that streams tributary to lake Erie have taken a similar length of time to cut their valleys and the gorges below their water-falls; and of Mr. Gilbert, that the gorge below Niagara Falls has required only 7,000 years or less. These measures of time carry us back to the date of the Little Falls quartz-workers, when the ice-sheet of the last glacial epoch was melting away from the basins of the Upper Mississippi and of the Laurentian lakes.

Plants and animals doubtless followed close upon the retiring ice-border, and men living in the region southward would make journeys of exploration to that limit, but probably they would not take up their abode for all the year so near to the ice as Little Falls at the time of the Fergus Falls and Leaf Hills moraines. It may be that the chief cause leading men to occupy this locality, so soon after it was uncovered from the ice, was their discovery of the quartz veins in the slate there and on the Little Elk river, affording suitable material for making sharp-edged stone implements of the best quality. Quartz veins are absent or very rare and unsuited for this use in all the rock-outcrops of the south half of Minnesota that had become uncovered from the ice, as well as of the whole Mississippi basin southward, and this was the first spot accessible whence quartz for implement-making could be obtained. While the deposition of the valley-drift at Little Falls was still going forward, men resorted there, and left, as the remnants of their manufacture of stone implements, multitudes of quartz fragments. By the continued deposition of the modified drift, lifting the river upon the surface of its glacial flood-plain, these quartz chips were deeply buried in that formation. The date of this valley-drift must be that of the retreat of the ice of the last glacial epoch, from whose melting were supplied both this sediment and the floods by which it was brought. The glacial flood-plain, beneath whose surface the quartz fragments occur, was deposited in the same manner as additions are now made to the surface of the bottom-land; and the flooded condition of the river, by which this was done, was doubtless maintained through all the warm portion of the year, while the ice-sheet was being melted away upon the region of its head waters. But in spring, autumn and winter, or, in exceptional years, through much of the summer, it seems probable that the river was confined to a channel, being of insufficient volume to cover its flood-plain. At such a time this plain was the site of human habitations and industry. After the complete disappearance of the ice from the basin of the Upper Mississippi, the supply of both water and sediment was so diminished that the river, from that time till now, has been occupied more in erosion than in deposition, and has cut its channel far below the level at which it then flowed, excavating and carrying to the Gulf of Mexico a great part of its glacial flood-plain, the remnants of which are seen as high terraces or plains upon each side of the river.

A general discussion followed, and Professor Haynes showed from his collection, some slightly weathered implements of palæolithic forms which he did not consider to be palæolithic implements.

Professor Morse alluded to the care with which these questions are now studied and the significance of the results obtained.

The President concluded the discussion, stating that all these discoveries of recent years show that man had occupied a portion of North America, from the Mississippi river to the Atlantic ocean, at a time when the northern part of the United States was covered with ice, and that at this early period he must have been contemporaneous with the mastodon and mammoth, south of the great ice barrier of the north, the southern border of which had been so well traced in the several papers read this evening.

The mystery of the bed of quartz chips and rude implements, under the drift at Little Falls, Minnesota, had, he thought, been most satisfactorily explained by the facts brought forward by Mr. Upham, relating to the occurrence of surface quartz-veins near and north of Little Falls, the first available locality for that rock after the recession of the ice. A similar condition exists at Trenton, where the argillite implements are found in the gravel, while the rock from which they were probably made is found in place a short distance to the northward. The only two implements yet known from the Ohio gravels were made of pebbles.

In this connection, the rude chipped implements described by Col. C. C. Jones from the river drift of the Nacoochee valley, must not be overlooked, and it is reasonable to expect the discovery of the implements of man in any of the deposits of the river-drift in the southern states.

When we compare the facts now known from the eastern side of the continent, with those of the western side, they seem to force upon us to accept a far longer occupation by man of the western coast than of the eastern; for not only on the western side of the continent have his remains been found in geological beds unquestionably earlier than the gravels of the Mississippi, Ohio and Delaware valleys, but he had at that early time reached a degree of development equal to that of the inhabitants of California at the time of European contact, so far as the character of the stone mortars, chipped and polished stone implements, and shell beads, found in the auriferous gravels, can tell the story. On the Pacific coast, where the conditions of life were more favorable, he had passed beyond the palæolithic stage before his works were buried in the gravels under the beds of lava; while at a later period on the Atlantic coast he was still in the palæolithic stage. Either this must be accepted, or else the geological changes on the Pacific coast have been entirely misunderstood; for we can no longer question the many instances of the discovery of the works of man, and also of his bones, in the Californian gravels. The same story is told by the beautifully chipped implement of obsidian found by Mr. McGee in the quaternary deposits of Lake Lahontan in Nevada.

It is also of importance to recall that it is at the north, across

GENERAL MEETING, APRIL 4, 1888.

The Vice President, Prof. G. L. GOODALE, in the chair.

The following obituary was read:

A NOTICE OF THE LIFE OF THE LATE RICHARD C. GREENLEAF.

BY SAMUEL WELLS.

RICHARD CRANCH GREENLEAF was born in Cambridge, Mass., in 1809 and died in Boston on August 3, 1887. At the early age of thirteen he entered the dry goods business in Boston and continued with great industry and activity to devote himself to work until his death. As the senior member of the house of C. F. Hovey & Co., he was the oldest merchant in that department of business in the city. In his business relations he was esteemed and respected for his strict integrity and freedom from all guile. He was a leader among those Boston merchants who have proved by their lives that it is possible to be always honest, true and pure and yet be successful.

With all his devotion to business he was interested in works of philanthropy and the pursuit of science. He was at all times generous to others not only with his money, but with his time, and no one ever called upon him, even in his busiest hours, without receiving a kindly reception and an attentive hearing.

He was interested in the Home for Aged Men and succeeded the Hon. Otis Norcross as its President. He was in the government of the Institute of Technology for several years and was for some time Vice President of the Franklin Savings Bank.

Mr. Greenleaf was married early in life to Miss Mary P. Whitney, daughter of Rev. Peter Whitney of Quincy. Mrs. Greenleaf is still living and their only child, Dr. Richard C. Greenleaf, now resides at Lenox in this state.

It is, however, with his interest in natural history that this Society is especially concerned. His general knowledge of organic life was extensive, but his particular study was the use of the microscope. The facility with which this instrument can be used in the evening was evidently one of the reasons that attracted him to it, as he was seldom away from his place of business during the daytime. He acquired a large and valuable collection of microscopical apparatus and paid much attention to the construction and use of high power objectives. It was largely due to his liberality and encouragement that the late Robert B. Tolles was enabled to take up his residence in Boston and progressively improve the construction of his objectives until his reputation as a skilful optician became world-wide.

Mr. Greenleaf understood thoroughly the theory and construction of the microscope and his skill in its manipulation was excellent. For his particular study he selected a group of algæ known as the Diatomaceæ, and was one of the earliest students of this family in the country. He made a large collection of them and of the literature descriptive of their varied and beautiful forms. About 1860 or 1861 he found a new and finely ornamented species which he named *Stauroneis Stodderii* in honor of his friend the late Mr. Charles Stodder, a member of this Society for many years, and an authority on the Diatomaceæ. This species is described in a paper "On Extreme and Exceptional Varieties of Diatoms, etc.," by F. W. Lewis, M.D., published in the Proceedings of the Academy of Natural Sciences of Philadelphia, January, 1865.

In 1869, Mr. Greenleaf made a communication to this Society on the subject of "The Double Plate of Aulacodiscus Oregonus." It is unfortunate that so careful an observer did not favor us with more of the results of his work.

Mr. Greenleaf became a member of this Society on December 5, 1860, and gave freely of his time and money to its purposes, especially in the department of microscopy, during the rest of his life. In 1870 he was chosen a member of the committee on microscopy, which made him a member of the Council. In 1871 he was elected second Vice President and continued to hold that office until 1874.

In 1877 Mr. Greenleaf with Dr. A. D. Sinclair presented to the Society 477 slides of microscopical objects prepared by Mr. William Glen, a valuable and interesting addition to the collection of slides. Mr. Greenleaf further manifested his interest in this Society by bequeathing to it his microscopical library containing several rare and valuable works, his apparatus and collection of slides, consisting of two Tolles' stands, one large and one small, nine objectives, and a variety of accessory apparatus, also about 2150 slides of which about one-half are diatoms and the rest anatomical, botanical, entomological and miscellaneous.

In the death of Mr. Greenleaf, the Boston Society of Natural History has sustained a great loss; those who were associated with him as officers and members feel it as such a personal grief that they will not soon forget his kindly advice and generous aid.

The following paper was then presented:

THE DEVELOPMENT OF THE OYSTER WITH REMARKS ON ALLIED GENERA.

BY ROBERT T. JACKSON.

The paper here presented is a preliminary paper on the later development of the oyster, with studies of allied genera. In the portion treating upon oysters, I have entered more into detail than was my first intention, but this seemed necessary in order to make a reasonably clear presentation of the facts.

Bibliographies of the development, life-history and culture of the oyster, are to be found in the works of Professors Brooks (4)[1] and Ryder (21), and Dr. R. Horst (7). A comprehensive essay on the life-history of the oyster has been published by Prof. John A. Ryder (25), and many papers exist in the Reports and Bulletins of the United States Fish Commission, from 1880–86 inclusive.

The investigations were carried on by me as a pupil of Prof. Alpheus Hyatt, and the main lines of research are similar to those followed by that author in his studies of the development of fossil Cephalopods. An attempt has been made to apply his classification to the later development of the oyster, and the stages of growth have been named[2] in accordance with his system (13), which was presented before the Society November 16, 1887.

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[1] References to papers quoted are referred to in the text by numbers in parentheses, of which a list will be found on p. 548.

[2] It is necessary to anticipate by means of a note a brief description of two names used in the text, in order to make clear their meaning in the first part of the paper. The adult shell of cephalous molluscs has been called the conch or true shell, and the young first formed shell on account of its differences, the protoconch. Similarly the young shell of Dentalium has been named the periconch. The adult double shell of an oyster is believed to be the homologue of the adult single shell of cephalous molluscs, and in view of its double character I suggest for it the name *dissoconch* (double shell). The first formed shell of an oyster is strikingly different from that which immediately succeeds it, and which is retained throughout the rest of life. It is different in form, histological structure, and covers very different organic soft parts. It is thought to be the homologue of the protoconch of cephalous molluscs and the periconch of Dentalium, and is, therefore, named the *prodissoconch* (early double shell). The detailed consideration of the reasons for this nomenclature is given on pp. 540, 542–543.

The stages described and named in that essay, as the protembryo, mesembryo, metembryo, neoembryo and typembryo, are to be found in following the early development of the oyster, though the concentration of development[1] is so great that they overlap one another. In the present paper the first application of the theory will be to the early single-muscled stage.

The first oyster material which I had for study was some very young spat sent to Professor Hyatt, by Prof. J. A. Ryder. During the summer of 1887, a large amount of material was collected at Buzzards Bay, Massachusetts, where oysters were secured on artificial cultch of pottery, wood and glass,[2] as well as on natural cultches of shells and stones. The studies of fossils were made while arranging collections as Professor Hyatt's assistant in the palæontological department of the Museum of Comparative Zoölogy. I also had free access to the collections of the Boston Society of Natural History.

Before turning to scientific considerations, a point in the life-history of the oyster is worth noting. One of the most successful spatting grounds at Buzzards Bay, is a sand spit in South Wareham, formed by the dividing waters of the tide, as it rises and flows on the one side to Buttermilk Bay, and on the other to Onset. The strength of the tide is very great at this point. The bar at low tide was bare for about four hours during the time when oysters were setting most abundantly late in July and early August. Here, then, the young oysters, which are exceedingly small when first attached, bear exposure for several hours daily to the air and sun, which dries up all appearance of moisture on the rocks and shells to which they are attached. Further, the spat not only sets and grows but develops quite as rapidly during summer as in localities covered by water all the time. They are removed in late autumn by the oystermen to deeper water, and no oysters reach maturity on the bar.

Lamellibranchs are divided into three groups, according as the adults have a single adductor muscle, monomyarians; two equally developed muscles, dimyarians; or again, two muscles, one large and functionally the most active, the other smaller, heteromyarians.[3] It is of great interest to know what are the relations between these groups, and it is believed that the later development of the oyster throws light on the problem.

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[1] For Professor Hyatt's theory of the concentration and acceleration of development, see reference No. 12.

[2] The details of the methods of procedure have been briefly described in "Science" since this paper was read. See reference No. 14.

[3] Those grouped as heteromyarians do not always have two muscles.

DEVELOPMENT OF THE SOFT PARTS.

The early embryological development of the oyster may be followed in the writings of Dr. R. Horst (6, 7), on the European oyster, *O. edulis* L. and Professor W. K. Brooks (4) on the development of our oyster, *O. virginiana* Lister. The later stages of development have been studied by Professor Huxley (8), and Dr. R. Horst (7), in the European oyster, and Professor J. A. Ryder, in our species.

The lamellibranchiate identity of the embryo is first emphatically marked when two valves are seen to have resulted from developing growth of the preconchylian gland (Horst's (7) fig. 14). The mouth and anus, when developed, arise in close proximity on the ventral aspect of the embryo (Brooks' (4) fig. 38), a generalized molluscan embryo characteristic. The velum which existed before this stage is clearly marked off, lying directly above the mouth.

A little later (Horst's (7) fig. 15), the development of the first adductor muscle begins in the middle anterior part of the body, and close to the dorsal margin of the velum. The retractor muscles of the velum and liver develop. The anus revolves in the plane of the valves through a considerable angle toward the dorsal aspect of body (see Brooks' (4), figs. 38–44). The intestine by interstitial growth makes a single loop-like curve on the left side; this with some other slight changes brings us to the stage figured by Professor Huxley (8) (see this paper fig. 1, pl. IV). Ryder (23), in remarking on this stage, notes that the intestine is already flexed on itself, in much the same manner as in the adult, though it does not extend as far anteriorly, and its position is modified later by flexions of the stomach.

Professor Huxley (8), in speaking of the single adductor, says: "It is a very curious circumstance that this adductor muscle is not the same as that which exists in the adult. It lies in fact in the fore part of the body, and on the dorsal side of the alimentary canal. The great muscle of the adult, on the other hand, lies on the ventral side of the alimentary canal and in the hinder part of the body, and as the muscles, respectively, lie on opposite sides of the alimentary canal, that of the adult cannot be that of the larva which has merely shifted its position; for in order to get from one side of the alimentary canal to the other, it must needs cut through that organ. But, as in the adult, no adductor muscle is discoverable in the position occupied by that of the larva, or anywhere on the dorsal side of the alimentary canal, while on the other hand there is no trace of any adductor on the ventral side, in the larva, — it follows that the dorsal or anterior adductor of the larva must vanish in the course of development, and that a new ventral or posterior adductor must be developed to play the same part and replace the original muscle functionally, though not morphologically." He also notes that the cockle has at first, like the young oyster, only one adductor, which answers to the anterior of the two adductors which the cockle possesses in the adult. This is up to the present time all that has been known concerning the adductor muscles of the young oyster.

The next stage, fig. 2, pl. IV, in the development which I have to consider, is that of an oyster which had completed its prodissoconch and a very slight spat growth had taken place on the ventral margin. The specimen, preserved in weak alcohol, was removed lately from cultch on which it had grown in Buzzards Bay during last summer. The calcareous portion of the shell was dissolved with dilute acetic acid, and the main features of the anatomy could then be seen. The velum had disappeared. The mouth from its previous ventral position (shown in fig. 1, pl. IV), had revolved dorsally, in the plane of the edges of the valves, similarly to the anus, but in the opposite direction, and had stopped beneath the still existent first-formed adductor muscle, fig. 2, pl. IV. This muscle apparently checked its farther revolution dorsally. Continuous with the mouth is the œsophagus which is directed dorsally. Immediately below the mouth is a large organ, which is probably the developing palps. The gills are developed considerably on the ventral aspect. The chief and most interesting feature of this stage, fig. 2, pl. IV, is the existence of a second adductor muscle, in the posterior portion of the body, of about the same size as the anterior adductor. This muscle occupies a position below the terminus of the intestine, which organ wraps around the posterior aspect of the muscle, as it does in later stages, and in all adult Lamellibranchs.

We have then the interesting feature of a monomyarian Lamellibranch, in its young stages possessing two muscles, situated relatively to the alimentary canal as they are in typical adult dimyarians. As noted above, the anal part of the intestine revolved dorsally during the early development of the oyster, and it is evident that the posterior muscle when formed must have originated on the ventral aspect of that organ. If the posterior muscle were developed on the dorsal side of the intestine it would always have retained that relative position, as the permanent anterior adductor of dimyarians does in relation to the mouth and œsophagus. It does not seem likely that the intestine would first force itself past an existing muscle, and then, when it got on the dorsal side, wrap its terminal part around the dorsal aspect of that muscle, as it does in all adult Lamellibranchs. One of the striking characteristics of the ostrean prodissoconch is, that the umbos point posteriorly, as shown in fig. 2, pl. IV. This is contrary to all figures of developing dimyarians that I have seen, as in them the umbos point anteriorly.

In Ostrea indisputably the anterior adductor is first developed. In Cardium after Lovén (18), as mentioned by Huxley (8), also in the figures by Lovén of Modiolaria and Montacuta, in Pisidium after Lankester (17) and in Anodonta according to Schierholz (26), the anterior adductor is first developed. I have only found two exceptions to the general rule of the anterior being developed first. Lacaze-Duthiers, in his paper " Sur le Développement des Branchies" (15), figures a young *Mytilus edulis* with a posterior adductor, but no anterior. He notes, page 21, that he did not observe any anterior, and believes that the posterior adductor is first developed. He explains it, by the theory of arrested development, and compares this stage with the monomyarian Lamellibranchs, Ostrea and Spondylus. In Lovén's figure of Modiolaria, the anterior adductor is first developed, and, as it is so closely related to Mytilus, it seems possible that the distinguished authority, Lacaze-Duthiers, overlooked the anterior adductor of Mytilus. Again, his comparison of the single-muscled stage of Mytilus with Ostrea, as a case of arrested development, will hardly hold, as Ostrea in the young is typically dimyarian, and therefore must be considered as a branch from a dimyarian root, not an ancestral monomyarian type. At any rate, if I am not mistaken, Mytilus must be considered as an exception to the general rule. The second exception I have found is Unio, where Huxley (9) in his " Anatomy of Invertebrated Animals," page 416, quoting Rabl (20) says, that the adductor muscle is first single and answers to the posterior adductor of the adult. Unio also seems to be peculiar in having its shell originate as an undivided membranous cuticula,[1] whereas the Lamellibranchiate shell is typically divided from its initial stages onward (see Horst (6 and 7), Lankester (17), Hatschek (5) and other authors). It is anomalous in having the primitive oral invagination on the dorsal aspect of the embryo and in having the byssus gland originate in the posterior end of the body. So many peculiarities exist in the embryo of Unio, it may, we think, in view of the evidence, be safely assumed that the development of the posterior muscle first, is not typical and, therefore, not incompatible with the theory that the anterior is typically first developed in Lamellibranchs.

In Ostrea the mouth and anus develop ventrally, the anal extremity of the intestine revolves dorsally, the anterior adductor develops, at a stage not yet determined the velum disappears. The mouth and œsophagus revolve dorsally and stop on the ventral side of the anterior adductor. The posterior adductor has developed apparently on the ventral side of the intestine. When one compares this with the figures and descriptions of the development of the above mentioned genera (excepting Mytilus and Unio), together with the anatomy of the adults, it seems that there is a close uniformity of plan. The genera mentioned are not numerous, but they have been taken from widely separate groups of Lamellibranchs. There is then strong evidence in favor of the development of the anterior adductor first in Lamellibranchs, as the typical mode, and the development of the posterior adductor later, after the intestine has revolved into place, from its early ventral position. This theory also easily explains the constant relative positions of mouth and anus to the two adductors in the adults of dimyarians, or to the single adductor, where only one exists, as in monomyarians. This first formed muscle being the morphological equivalent of the anterior muscle of adults which retain it, and the evidence for its typical uniform first appearance being so strong, since it is presumably of phylogenetic importance, I venture to suggest for this early stage the name *antemonomyarian.*

It is seen that I have so far described two distinct stages of development in the anatomy of the young oyster. First, a single-muscled stage, the antemonomyarian, fig. 1, pl. IV, pointing towards a problematical ancestor, which in the adult condition had only one adductor muscle, and that in the anterior portion of the body. The figure of this stage shows the early formed velum to be still existent, but it is not likely that the early antemonomyarian adult ancestor possessed a velum. It exists here presumably because of the lapping over of stages, due to concentration of development, which was noted as being most marked in early embryonic development. The second stage is the two-muscled stage, dimyarian, fig. 2, pl. IV, pointing to an ancestral adult form which had two muscles like the typical dimyarian. The shell which covers these stages is continuous in outline, and I have not made out any indication of change of form or structure to coincide with the change in the soft parts.

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[1] This same feature has been observed by Professor Brooks in Anodonta (2).

The next stage of a developing oyster is shown in fig. 3, pl. IV. This is a younger spat stage than has been previously figured, but shows great changes from the last, fig. 2, pl. IV. No trace of an anterior adductor was made out, but the posterior adductor can be seen just on the limits of the prodissoconch. Palps and gills were both seen and they have revolved dorsally from their previous ventral position. The gills are filamentous in structure, similar to those described in young Mytilus by Lacaze-Duthiers (15). In the specimen from which my figure was drawn, the outer limits of the filaments appeared to be free; but this may not have been the case, as it was difficult to see through the somewhat opaque shell. In fig. 4, pl. IV, drawn from a living oyster of a little older growth, the tips of the filaments are joined by a continuous, connecting membrane, similar to that figured in older stages of Mytilus by Lacaze-Duthiers (15).

The intestine wraps around the adductor muscle, as in fig. 2, pl. IV, and in older stages, fig. 18, pl. VII. The mouth parts have revolved dorsally, yet not through so great an angle from the position they formerly occupied in fig. 2, pl. IV, as seen in the adult, fig. 18, pl. VII. Professor Ryder (23) remarks, in speaking of a similar figure of a spat, which was taken from a later stage of growth, that the mouth opens downwards and not so directly forwards as in the adult; evidently it had not yet completed its upward revolution.

I succeeded in growing spat on glass slides, and excellent opportunities for studying them alive, under the microscope, were consequently at my command. When undisturbed and quietly feeding, the mantle stretches out to the margin of the shell on all sides, and even protrudes considerably beyond it. It moves actively, being constantly retracted and extended by the radial muscles[1] described by Professor Ryder (23). The marginal tentacles are also constantly in motion, being continually elongated and retracted. When elongated they are used with a tentative, feeler-like motion, and if irritated are capable of extreme prolongation and then exhibit great activity. The gills and palps move frequently and suddenly.

My studies corroborate Professor Ryder's figure of a specimen of a spat stage in all general points, except the convolutions of the intestine, which I did not succeed in making out.

During later stages of growth, the soft parts rapidly assume the positions which they occupy in the adult, fig. 18, pl. VII. The mouth parts are revolved towards the umbos, and the anus and adductor are revolved in the opposite direction, towards the free ends of the valves, until they attain a position at an angle of about forty-five degrees from the position which they had in the two-muscled stage, fig. 2, pl. IV.

In the dimyarian stage of the young oyster, fig. 2, pl. IV, the relative position of the axes of the body to the hinge axis of the shell[2] resembles an adult dimyarian Lamellibranch, fig. 15, pl. VII. The hinge is dorsal, free edges of the valves ventral, the mouth and anus lie at either end of the equal valves, so that the antero-posterior axis[3] is nearly parallel to the hinge axis. In the adult oyster, fig. 18, pl. VII, this relation is different. The mouth lies close up under the hinge line, marking this as the anterior end of the body. The free ends of the valves are at the posterior extremity, the gills lie on the ventral side, and the intestine on the dorsal.[4] The antero-posterior axis passes nearly through the umbos and centre of the valves and at an angle of about ninety degrees from the hinge axis. This revolution of the axes Ostrea is seen by comparing figs. 1, 2, and 3, pl. IV, and fig. 18, pl. VII.

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[1] In my fig. 3, pl. IV, the radial muscles were not seen; but they are readily seen in living specimens from which the shell has been partially broken away.

[2] The hinge axis refers to an ideal line drawn through the hinge area, and coinciding with the axis of motion of the valves, as shown in figs. 15–18 inclusive, pl. VII. My attention was called to the value of this line in considering the theory of the revolution of the axes, by Mr. B. H. Van Vleck of the Boston Society of Natural History.

[3] The antero-posterior axis, as shown in figs. 15–18, pl. VII, is considered as passing through the mouth and middle of the posterior adductor muscle and nearly or quite coinciding with the termination of the intestine.

[4] The fact that the umbos in the oyster are at the anterior end of the body has already been pointed out by several authors, and Hyatt (10) figures an oyster drawn over a clam to show their relations. Ryder (23), page 787, notes the rotation of nearly ninety degrees that must take place from my fig. 1, pl. IV, after Huxley, to bring about the adult relation of parts.

In other monomyarians, as Pecten and Anomia, the mouth lies close up under the umbos, which are in the median plane of the shell; thus the relations of the axis to the shell are similar to those of Ostrea.

In heteromyarians, as Mytilus, Modiola, fig. 16, pl. VII, Perna, fig. 17, pl. VII, and Avicula, a distinctly transitional series may be studied, in which the relations of the axes are changed from what exists in the typical dimyarians, fig. 15, pl. VII, to what we find in the single-muscled group, fig. 18, pl. VII.

In the clam (*Mya arenaria*), fig. 15, pl. VII, the adductor muscles lie at either end of the longer axis of the shell, the mouth lies close up behind the anterior adductor, the anus overlies the posterior muscle, the umbos lie dorsally. The antero-posterior axis is nearly parallel to the hinge axis.

It is seen that in *Modiola plicatula*, fig. 16, pl. VII, the mouth and anterior adductor have revolved dorsally, so that they lie much nearer to the umbos than in the clam, fig. 15, pl. VII; similarly, the posterior adductor and anus have revolved in the opposite direction, and occupy a position much further removed from the hinge line than in the clam. The antero-posterior axis lies at an angle of about 25° from the hinge axis.

In *Perna ephippium*, fig. 17, pl. VII, the mouth lies close up under the umbos, but the umbos are not in the median plane of the shell. No anterior adductor was found, but it probably exists in closely related species.[1] The posterior adductor and anus are still further removed from the hinge line than was the case with Modiola. The antero-posterior axis lies at an angle of about 50° from the hinge axis.

A revolution of the axes similar to that traced in oysters, and in the above serial groups, may be seen in *Mülleria lobata*, a widely separate genus. According to Adams (1) and other authors, it has two muscles when young; but, when fully grown, one muscle.

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[1] Mr. Purdie, of New Zealand, in a paper (19) recently published, notes that *Mytilus latus* has no anterior adductor, while two otherwise closely related species *M. edulis* and *M. magellanicus*, have anterior adductors. In *M. latus*, the loss of the anterior muscle is accompanied by a movement of the one existing muscle inwards, nearer the central plane of the valves, where its mechanical action is more effectual.

The anterior muscle has disappeared, and the posterior, which is retained, lies in the middle lower portion of the shell, in a position closely similar to that of an oyster.[1]

The revolution of the axes in Lamellibranchs, relatively to the axis (hinge) of motion of the valves, is thus seen to be closely correlated with the reduction and final loss of the anterior adductor, together with the increase and final exclusive retention of the posterior.

THE SHELL.

The two valves of an adult oyster are together homologous with the single valve of adult cephalous molluscs. Both originate from the preconchylian gland, one as a single, the other as a paired organ. The adult shell of cephalous mollusca is termed a conch. Therefore, in view of its homology and double character, I suggest the name *dissoconch*[2] for the shell of an adult oyster, and similarly the same terminology is applicable to the adults of other Lamellibranchs.

The shell of oysters, at different periods of growth, presents striking dissimilarities. There are three well-marked stages of growth, as pointed out and figured by Professor Ryder (21):

(1) Prodissoconch, symmetrical fry stage; (2) Silphologic (spat) stage, flat left lower valve, and convex upper right valve; (3) Adult, flat upper right valve and concave lower left valve.

We will now consider the form and structure of the shell of the oyster, commencing with the earliest shell and continuing through the spat stages of growth.

The early prodissoconch as figured by Ryder (22), figs. 1–2, and others, is nearly discoidal, flattened into a straight line at the hinge area, fig. 1, pl. IV. The valves are convex, equivalvular, with concentric lines of growth, but farther apart ventrally, and closely underlying one another dorsally, so that as growth continues the centra are pushed forward, and lifted upward and outward until the close of the stage. By this method of growth, relatively high umbos are developed and the early straight hinge line is finally lost being superseded by one of a gentle curvature, fig. 5, pl. IV. At the close of the prodissoconch stage and before any spat growth has taken place the valves are deeply concave and nearly equal. The lower left valve is, however, somewhat larger and deeper than the upper right valve as seen in fig. 6, pl. IV. The umbos are always inclined upwards at about the same angle, and are directed dorsally as shown in above studies, fig. 2, pl. IV. They invariably point to the left of the observer, viewing them from above, when fixed to the object of attachment.[1]

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[1] This case is particularly interesting, as the change takes place much later than in the oyster. The two-muscled stage is not an embryonic one, but of a much older period of development. In Aetheria, a near ally, the two muscles are retained throughout life, in a partially revolved position.

[2] Δισσός, double; Κόγχη, shell.

The prodissoconch is, as described by Ryder (22, 24), homogeneous and laminar in arrangement, "not prismatic" as in the immediately succeeding stages of spat growth. It is composed of lime infiltrating an amorphous matrix of conchyolin, as may be seen by treatment with acid. One of the marked characters of the prodissoconch is the uniformity of shape and size found in different individuals. It has not the ostrean tendency to variability which is noticeable in later stages.

The height of the fully developed prodissoconch is about $\frac{1}{90}$ of an inch. It has already attained a size much greater than it had when first attached, according to Ryder's (22) figure of a recently attached individual.

The left attached valve turned over and viewed from the lower side is seen to be exactly like the right free valve in general appearance. It is not flattened nor are there other indications to mark where it was attached, so that this attachment is evidently of a very superficial and delicate nature.

Ryder (22) figures an oyster just after it has set, which seems very clearly to be effected by means of the mantle reflected over the edge of the lower valve. There is, in the later prodissoconch and spat stages, an organic conchyolin attachment of the shell itself, thus described by Ryder (24): "The cementing material seems to be the organic matrix of the shell which forms a perceptible layer on the outside of the valves, and which constitutes the epidermis or periostracum of the oyster." In the prodissoconch, as well as spat stage, the cement is so firm that, as Ryder says (22), the shell may be broken before it can be removed. To prove that this is an organic cement, if we put a drop of water on a dead, young shell, and allow it to remain a short time, it can be readily picked up on the point of a knife. Quite large spat may be removed when dead (*i. e.*, the organic matter inert) by soaking or boiling. Treatment with acid, on the other hand, does not loosen the hold of the shell. Quantities of young spat die during the summer, yet few dead shells are found on cultch, because soon after death the organic cement decays and is dissolved, and the shell falls off. Dead oyster shells exposed to water or weather sooner or later loosen their hold upon the stone or other object to which they had attached themselves when young. Professor Huxley (8) notes that the European oyster separates naturally from unfavorable objects of support; and that the separation takes place naturally at an early stage can be seen markedly in many fossil members of the family. Conversely, the calcareous plug of Anomia, which appears to be fixed to the object of support by a purely calcareous union, remains indefinitely after the death and separation of the individual to which it belonged. All our evidence is therefore in favor of the assumption that the cement by which the oyster is attached is wholly organic.

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[1] Professor Ryder informs me by letter that he has never seen an exception to this nor have I, though I have sought for umbos pointing to the right.

With the introduction of the spat stage, a fundamental histological difference arises abruptly in the structure of the shell. As we have stated above, the prodissoconch consists of lime infiltrating an amorphous matrix of conchyolin, but in the initial spat stage the first layer of shell is deposited in a "tessellated or prismatic" manner in a horny matrix, as described and figured by Professor Ryder (22, 24). Soon after the formation of the spat stage, the subnacreous, white, porcellanous layer begins to be deposited on the yellowish-brown, prismatic layer, first making its appearance as irregular blotches in the centre of the valve. These two layers continue throughout the rest of the life of the oyster, and together, though in disproportionate degree, build up the massive adult shell. The prismatic layer always remains thin, as may be readily seen by sections, or by treating an adult with acid, when the remaining conchyolin of the prismatic layer will separate from the overlying subnacreous layer like a dissected skin.

The protoconch of Owen, in Cephalopods, is the early shell which precedes the conch, or true shell. Professors Hyatt (13) and Brooks (3), consider the protoconch in cephalous molluscs as the univalve shell of the fully developed veliger, and probably derived from the periconch of Scaphopods.[1] It is seen from the study of Ostrea that the true shell, that which characterizes the adult, originates with the introduction of the spat stage. The earlier shell is strikingly different. It is the completed shell of the veliger antemonomyarian and dimyarian stages. It is distinctly the homologue of the protoconch and periconch. In the oyster, however, this shell is not single, but double-valved, and, therefore, deserves a distinct name, as it precedes the dissoconch or true shell. I suggest the name prodissoconch[2] or early double shell. A prodissoconch similar to that of Ostrea has been found in many allied genera.

The spat stage in *Ostrea virginica* as a whole is divisible into five stages. These five stages of growth are laid down one after another, and are more or less clearly marked in every regular growing, unworn, young specimen, fig. 7, plate v. To study these stages to the best advantage specimens should be sought growing in protected places, as the wear of sand and waves destroys their demarcation very rapidly. Some spat which I found in the inside whorls of dead Busycons, and others which I secured on artificial cultch of glass in drain pipes, and on inverted flower pots, retained the markings clearly.

The true larval or silphologic stages of Professor Hyatt (13) begin, according to the classification of that author, with the formation of what Owen called the apex of the conch, or true shell. It is shown above that the spat marks the beginning of the dissoconch (true shell) in Ostrea; therefore the stages into which it is divisible are here considered as the silphologic stages.

First silphologic stage (figs. 10, 11, plate v).—The spat growth begins along the lower margin of the prodissoconch valves figs. 2 and 6, pl. IV, and throughout life under normal conditions the most rapid growth is in this direction. The growth rapidly pushes up the sides of the valves, and between the hinge areas of the latter, fig. 8, pl. v, lifting them upwards, and separating them. A little to the right of the umbo of the lower left prodissoconch valve, as seen from above, in the initial stages of spat growth, is a notch which indicates the origin of the ligamental groove of the lower valve. This is seen clearly in fig. 9, pl. v.

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[1] Professor Brooks (2) says that the embryonic shell of Anodonta is at first a cup, covering what is to become the dorsal surface of the embryo and is, therefore, homologous with the embryonic shell of Gasteropods and he compares it closely to the first shell of Dentalium. See (16).

For the relations of the periconch to the protoconch, and the origin of the term periconch. See (13).

[2] Πρό, before; Δισσός, double; Κόγχη, shell.

It is necessary to describe the left and right valves separately. The upper right valve, fig. 10, pl. v, is directly continuous with the prodissoconch valve and follows the curve of that stage though in a lessening degree. It spreads out laterally on the hinge line in a descending curve. The lower left valve, fig. 11, pl. v, starts as does the upper, following the curve of the early valve. When this curve has been followed for an extremely brief period, the valve suddenly flattens, and becomes closely related to the surface of attachment. The result of this, is that a slight groove runs around the border of the spat valve, beyond which it is abruptly continuous with the flat later growth, as has already been mentioned by Professor Ryder (23). I have, however, to note a peculiar and significant exception. Sometimes instead of becoming flat and closely related to the object of attachment, the spat valve of this stage is continuously curved throughout its extent, and not at all flattened. It then closely resembles the upper valve of the same stage in shape. This curved shape is held, as far as I have made out, only on rough objects of attachment. Seeking for such material on rough stones and shells, one will always find some valves more or less curved in their earliest stages. This is very interesting, as showing the modifying influences of environment, on a very young stage where heredity might be supposed to fashion the form, with overpowering force.

Second silphologic stage (figs. 12, 13, pl. vi).—In the second stage the upper valve is in form a continuation of the first stage. The lower valve when flat begins to spread out over the object of attachment by wing-like extensions of its anterior margins. In the lower valve this stage commonly makes a shoulder, on its anterior border by its increased growth, where it comes in contact with the outer limit of the first silphologic stage, fig. 13, pl. vi. Similar shoulders also mark the periods of growth of later stages in the lower valve. The lower valve may remain concave throughout this stage as in the first silphologic stage. The shells during the first two stages are characteristically even and rounded in outline.

Third silphologic stage (fig. 14, pl vi).—The upper valve in smooth regular growing specimens still holds the simplicity of outline and conforms closely to the angles of curvature laid down in

Professor Putnam gave an account of observations made upon two species of wasps, while in camp at the Serpent Mound, Ohio, in September. One species carried large green caterpillars long distances to holes previously made, and travelled in a direct line to the hole, although it was impossible for the insect to be guided by sight of the spot ahead, owing to the rough ground and tall weeds. He thought that possibly the wasp may have been guided by the wind, but the sighting of some high object on the line followed may also have been the means of guidance.

The other species observed carried the caterpillar to the edge of an ant hole and let the ants do the burying by pulling the caterpillar into their hole, which they immediately proceeded to do. In this case it would seem that the wasp had deposited its eggs in the caterpillar before taking it to the ant hole, but no observations were made to prove this point. The actions of the wasp were conclusive that it was searching for an ant's nest, which was eventually found, and its aimless way of travelling was in marked contrast to the species which had prepared a hole for the reception of the caterpillar.

GENERAL MEETING, JAN. 18, 1888.

The President, Prof. F. W. PUTNAM, in the chair.

Dr. G. L. Goodale spoke of some recent experiments on the germination of seeds, undertaken at the Botanic Laboratory in Cambridge by four students and himself.

Mr. Setchell then described the effect of immersion in various fluids — some toxic — upon germination and growth of sunflower seeds.

Mr. K. Miyabe spoke of the development of radicle and rootlets in the same seedlings.

Mr. W. F. Ganong described the extent of germination of seeds placed in water from which oxygen had been removed.

Mr. F. H. Newell read the following paper on the fossils of the

Niagara group from Northern Indiana, showing a collection of cephalopods upon which Professor Hyatt commented after the reading of the paper, calling attention to the special importance of many of the specimens.

NIAGARA CEPHALOPODS FROM NORTHERN INDIANA.

BY FREDERICK H. NEWELL, S. B.

The cephalopods described below form a portion of the material collected during a reconnoissance along the Wabash river in the summer of 1887. This reconnoissance was undertaken for the purpose of studying the structure of the rocks exposed by the river, with a view to determining the amount and kind of disturbance, if any, which that portion of the country has undergone.

For the identification of the various strata numerous fossils were obtained, and on careful examination of these I have found, among the cephalopods, several new species of considerable interest.

In this description the genera proposed by Professor Hyatt have been used.[1]

I am under especial obligations to Professor Hyatt for his invaluable suggestions and criticisms during the study of these fossils.

ORTHOCERATIDAE.

Genus ORTHOCERAS.

The genus Orthoceras (Breynius), according to the classification of Professor Hyatt, is "confined to straight and comparatively smooth longicones with simple septa and sutures; it equals group 17 of M. Barrande."

By these definitions all the brevicones and the banded annulated or striated forms of longicones are excluded.

Orthoceras crebescens Hall.

Orthoceras crebescens Hall, 20th Rept. State Cab., of N. Y., rev. ed. p. 413, pl. 19, figs. 1–3.

Orthoceras crebescens Hall, Pal. Ohio, II, p. 148, pl. 9, fig. 2.

Several specimens from Wabash City, Ind., are referred to this species from the close agreement to the descriptions and figures above noted.

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[1] See Genera of Fossil Cephalopods, Proc. B. S. N. H., XXII, 1883, p. 253.

The shell is large, straight; the transverse section is subcircular or oval from compression. The apical angle varies from 5° in the nearly circular casts to 7½° in the more compressed forms. Initial extremity and living chamber unknown.

The concavity of the septa equals an arc of from 97° to 110°, the variation being largely due to compression. The distance apart of the septa is such that 2½ to 3½ of these spaces equal the diameter of the shell. The sutures are nearly straight, but exhibit a tendency to form broad lateral saddles.

The siphon is large, central or slightly subcentral, varying from subcircular to elliptical. The portions of the siphon between the septa are not well preserved. Test unknown.

These forms should be compared to *O. crebistriatum*, *O. rectum*, *O. unionensis*, in Geology of Illinois, VI, p. 503, pl. 26.

Locality.—Wabash City, Ind.

ORTHOCERAS UNIONENSIS Worthen.

Orthoceras unionensis Worthen, Geol. Ill., VI, p. 505, pl. 26, fig. 4.

Shell small, straight; apical angle 3° in smaller part of shell; septa deep, subtended arc about 145°; distance of septa equals two-fifths of diameter of the shell. Test, living chamber, siphuncle and initial point unknown.

Several casts are referred to this species, on account of their small size and general outline. It is possible that this is a young form of *O. crebescens.* The best preserved cast measures in length 340 mm., diameter of largest closed chambers 29 mm., and diameter of smallest 8 mm.

Locality.—Wabash City, Indiana.

ORTHOCERAS RIGIDUM Hall.

Orthoceras rigidum Hall, Pal. N. Y., III, p. 344, pl. 70, fig. 3.

This species is represented by a fragment consisting of the cast of eleven closed chambers, apical angle 7½°; septa moderately convex; distant about one-seventh the diameter of the shell. Test, siphon and living chamber unknown.

Locality.—Upper portion of the Niagara Group at Peru, Indiana.

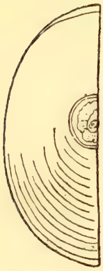
ORTHOCERAS OBSTRUCTUM n. sp.

Shell straight, gradually enlarging; transverse section broadly elliptical; apical angle 6°; initial extremity and living chamber unknown.

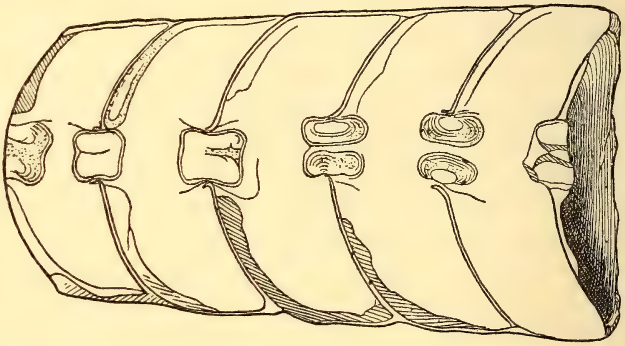
The septa are smooth, having a concavity equal to an arc of about 110°; the distance apart is one-third the diameter of the shell. The sutures are apparently straight; the outside of the cast, however, is too greatly weathered to show their exact direction.

The siphon is large and subcentral; its diameter at the aperture through the septa is 7 mm. or about one-fifth the diameter of the shell at this place. A longitudinal section gives a few markings which indicate a moderate expansion of the tube in the interseptal regions.

The characteristic feature of this species is the rosettes (the *anneaux obstructeurs* of Barrande). These rosettes extend 3 to 4 mm. above and below each septum, and are separated from each other by a space of about 7 mm. The small tube through the rosettes, the endosiphon, somewhat irregular in outline, is a trifle over 1 mm. in diameter. The section through the centre of the rosettes indicates their laminated or concentric structure.



Smallest septum.



Longitudinal section.

The test is unknown and there is no evidence of ornamentation on the cast. The moderate convexity of the filling of each air chamber is probably due to weathering of the exterior.

The plane of the illustration does not coincide with the axis of the siphon; but, at the smaller end of the shell, passes somewhat above the endosiphon, as shown on the half septum at the left of the figure.

Locality.—Wabash City, Indiana.

GENUS KIONOCERAS Hyatt.

This genus includes those Orthoceratidæ in which the longitudinal ridges are more prominent than the transverse striæ or ridges, when these are present. They are smooth throughout their entire length, equalling group 4 of M. Barrande.[1]

KIONOCERAS COLUMNARE.

Orthoceras columnare Hall, 20th Rept. State Cab., revised ed., p. 411, plate 19, figs. 4 to 8, pl. 24, fig. 1.

Shell straight, apical angle 7°, initial extremity and living chamber unknown. The transverse section varies from broadly elliptical to nearly circular.

The septa are thin; concavity equals an arc of 115° to 120°, this difference being due to compression; distance of the septa is a little less than one-fourth of the diameter of the shell.

The siphon is large, subcentral, broadly elliptical, measuring 10 mm. in diameter where the shell is 55 mm. across. A longitudinal section shows that it is tubular.

The surface of the cast shows the longitudinal ridges, eighteen in the entire circumference, with fine striæ between them and parallel to their length.

In the breadth of the intervals between the ridges, these Indiana fossils resemble *Kionoceras* (*Orthoceras*) *strix* Hall (Pal. Ohio, II, pl. IX), but in other respects agree closely with *K. columnare*.

Locality.—Wabash City, Indiana.

KIONOCERAS STRIX.

Orthoceras strix Hall and Whitfield, Pal. of Ohio, II, p. 149, pl. 9, fig. 3.

Shell large, straight; transverse section broadly elliptical; apical angle 10°.

Siphon subcentral, moderate size, smaller than in *K. columnare*. A longitudinal section of the Indiana specimens gives no satisfactory evidence of its character in the interseptal space.

External markings strong, with fine longitudinal striæ.

This species differs from *K. columnare* in the more rapid increase in size of the shell and in the smaller siphon.

Locality.—Wabash City.

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[1] Proc. B. S. N. H., XXII, p. 275.

KIONOCERAS ANGULATUM.

Orthoceras angulatum Wahl. See 20th Rept. State Cab., rev. ed., p. 413.

Fragments of this species are from Huntington, Wabash and Delphi, Ind.

GOMPHOCERATIDÆ.

GENUS GOMPHOCERAS.

The genus Gomphoceras of Sowerby includes those nautiloid species with constricted apertures, having straight shells. It differed according to the old classification from the genus Phragmoceras, which also had constricted apertures, merely in the straight outline, Phragmoceras having an arcuate shell.

According to the classification of Prof. Hyatt, Gomphoceras is restricted to those forms having symmetrically constricted T-shaped apertures, including thus the arcuate shells (formerly Phragmoceras) as well as the straight shells.[1]

GOMPHOCERAS WABASHENSIS n. sp.

Compare *Gomphoceras rectum* Barrande, Syst. Sil., II, p. 314, pl. 69, figs. 15-18.

Compare *Gomphoceras scrinium* Hall, 20th Rept. State Cab., N. Y., p. 410.

Shell is of medium size, straight, characterized by shape of living chamber and apertures; the closed chambers and test being unknown.

The living chamber in general outline is an ovoid with somewhat flattened base and a very slight angularity on the ventral side. In a vertical dorsi-ventral section, the slopes of the ventral and dorsal sides are very nearly equal, differing in this respect from the majority of Gomphoceratites; for, in these, as shown by Barrande, the ventral slope is usually greater than the dorsal. It thus corresponds exactly to the original definition of Gomphoceras. In horizontal section the chamber is subcircular, with the dorsi-ventral axis longer than the lateral. The chamber is largest at the base decreasing slowly in size on all sides to the area occupied by the apertures. The base of the living chamber is strongly convex with no saddles or lobes.

The T-shaped aperture is situated on the top of the living chamber, in a vertical view appearing symmetrically placed in the centre of figure. The sides of the shell folded in, approach in some specimens, to within 3 to 4 mm. In length the slit thus formed equals that of the dorsal opening, which crosses it at right angles, and also the length is about one-half the diameter of the living chamber. The dorsal aperture has a slight saddle, the back of the shell being bent forward in some of the specimens. Thus the aperture is widest at the three extremities, and narrow in the centre. The openings vary in width from 3 mm. in the narrowest places to 8 mm. near the extremities, and are proportionally narrower in the younger than in the older shells.

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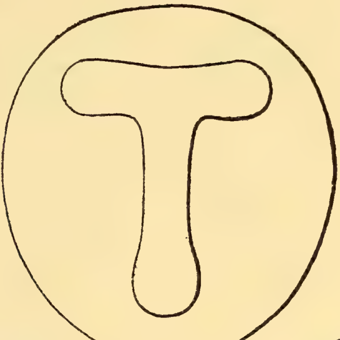
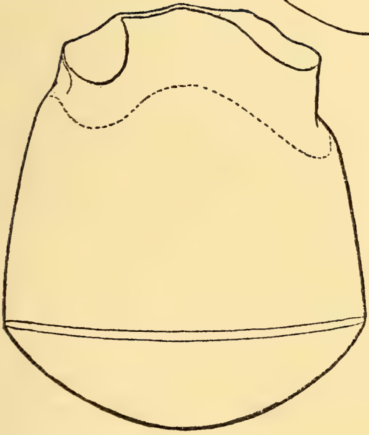
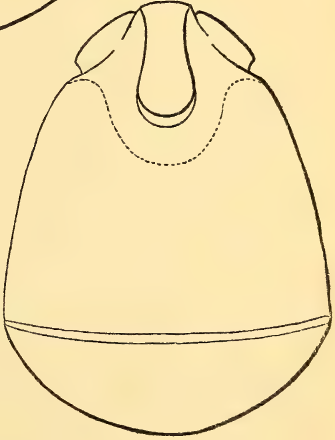
[1] See Proc. B. S. N. H., 1883, XXII, page 277.



Aperture.



Lateral view.



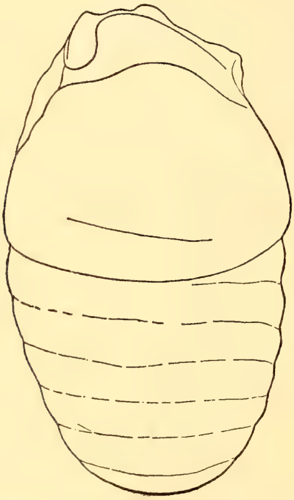
Ventral view.

The siphon is circular, 3 mm. in diameter in the larger specimens, and is situated from 5 to 8 mm. from the ventral side. Faint crenulations, not represented in the figures, appear on the base of the living chamber.

This species is founded upon several casts of living chambers, all devoid of test.

In the type specimen above figured the three greatest dimensions are :— dorsi-ventral diameter of base of living chamber, 47 mm.; lateral diameter 42 mm.; vertical, 55 mm.

The species resembling this most nearly are *G. rectum* Barr. (*Bohemia Etage* E,) and among American forms *G. scrinium* Hall. From the latter *G. Wabashensis* differs in being more nearly conical; that is, the horizontal sections decrease in size from the base of the living chamber up towards the apertures, while in *G. scrinium* the outer chamber swells slightly above the base and then decreases in area of horizontal section. The aperture also in *G. Wabashensis* is more nearly T-shaped, the median lobes coming so near together as to reduce the vertical portion of the aperture to a thin slit, while the aperture of *G. scrinium* approaches more nearly to the type of Acleistoceras (Hyatt).



Compressed form of Gomphoceras Wabashensis × ½.

Locality.—From the limestones at Harley Bros. quarry, Delphi, Indiana.

Closely allied to this species, and probably differing mostly in size and manner of preservation, are several specimens from Wabash

City. These are compressed laterally and though the outlines of the apertures are very dimly shown, yet the characteristic compressed T-shaped opening above described can be discerned. In outline, the living chamber agrees with *G. Wabashensis* in decreasing in size from the base upward. These specimens have several closed chambers attached. They show that in general shape the shell was nearly straight; the dorsal and ventral sides being both convex, the dorsal slightly more rounding than the ventral. The increase in size from the smallest chamber upwards is quite rapid. On the best preserved specimen, figured above, the dorsi-ventral diameter of the lowest suture, the sixth from the base of the living chamber, is 45 mm.; the base of the living chamber is 73 mm. and the distance between these two diameters is 50 mm. The thickness of the closed chambers averages a little less than 9 mm. The greatest vertical height of the living chamber is along the central vertical axis, which equals in length the dorsi-ventral diameter of the base.

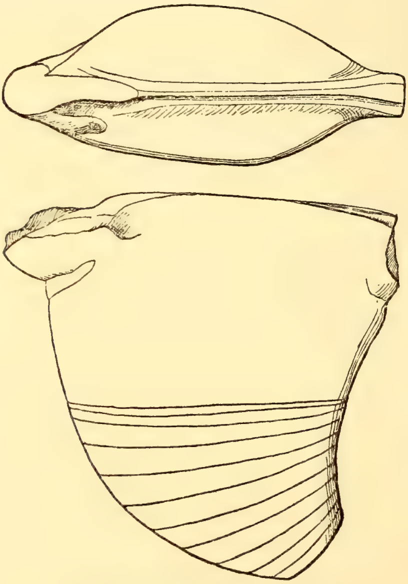
GOMPHOCERAS LINEARIS n. sp.

Compare *Gomphoceras* (*Phragmoceras*) *labiatum* Whitf., Geol. Wisc., IV, p. 302, pl. 20, figs. 1 and 2.

Shell of medium size, arcuate, increasing rapidly in diameter from the apex to the apertures; the ventral side is slightly concave, dorsal strongly convex; transverse section narrowly elliptical, ventral side angular, dorsal narrowly rounding. Apex unknown.

The living chamber is large, rhomboidal in lateral outline. Its bulk is fully two to three times that of all the closed chambers together. The length is one-fourth less than the dorsi-ventral diameter of the last septum. It increases in length and breadth to the region of the apertures where the side flaps turn abruptly toward each other making a long flat top parallel to the base of the chamber. The sides of the aperture approach so closely that they leave the slit connecting the ventral and dorsal regions scarcely a millimetre in width. The length of this linear slit (from which the species is named) is one-fourth greater than the dorsi-ventral diameter of the base of the living chamber, and also greater than the entire length of the shell, being proportionally longer than that in any species yet described. The ventral opening is elliptical and prolonged forward in a tube-like projection, but its entire length is not shown, the cast being broken. The dorsal opening is in general outline ovoidal and is also prolonged diagonally backward and upward into a tube. This dorsal tube joins the shell at a sharp angle and in the angle on the back are two sutures which unite about half-way up the sides. The back part of this tube is oval, but on the forward portion the sides are bent in and slightly recurved so that in the view from above the apertures appear to have two small lobes or folds pointing forward one on each side of a large median lobe.

The closed chambers increase in size uniformly. The transverse section of the smallest chamber is a narrow ovoid. Sections taken above this become more and more nearly elliptical, but always a little wider on the dorsal than on the ventral side of the centre. The dorsi-ventral diameter of the tenth septum from the base of the living chamber is one-third that of the base of the living chamber, and is distant, measuring on the ventral angle, a little less than one-half the length of the base of living chamber.

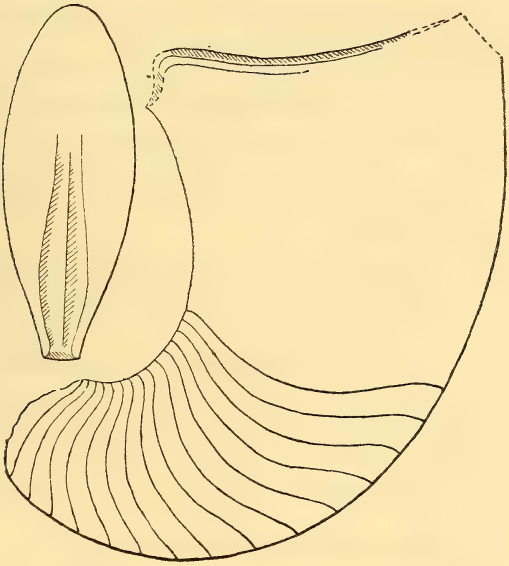


Vertical and lateral views × ½.

The septa are slightly convex downward. The sutures are nearly straight with no lobes nor saddles, and average about 3 mm. apart at the ventral angle and 5 to 8 mm. on the dorsal side. The specimen above figured was probably full grown as the septa adjacent to the living chamber are nearer together than those of younger age. The siphon has not been found, and the test and surface markings are unknown. The type specimen as illustrated is somewhat distorted, especially about the dorsal aperture. The dimensions of this shell are: total length from smallest chamber to dorsal opening 115 mm.; greatest dorsi-ventral diameter taken just below projection of apertures 88 mm.; transverse diameter, somewhat compressed, 45 mm.; height of living chamber 58 mm.

Locality.—Bridges Quarry, Wabash, Ind.

GOMPHOCERAS ANGUSTUM n. sp.



Vertical and lateral views. × $\frac{1}{3}$.

Compare *Gomphoceras (Phragmoceras) ellipticum* H. & W., Pal. Ohio, II, p. 152, pl. 8, fig. 11.

Compare *Gomphoceras (Phragmoceras) imbricatum* Barr., Syst. Sil., II, pl. 46.

Shell large, arcuate; transverse section narrowly elliptical; the dorsi-ventral diameter uniformly increasing from the smallest closed chamber up to the aperture. The ventral or concave side is subangular, the dorsal narrowly rounding. The apex is unknown.

The living chamber is large with a length at least a third greater than the dorsi-ventral diameter at the last septum; this length also about equals the dorsi-ventral diameter at the aperture. The greatest lateral diameter of the shell is from one-half to one-third these latter measurements. The sides of the shell are quite flat over the central area. At the aperture the side flaps turn in rapidly, contracting the middle of the aperture to a narrow channel.

The ventral opening of the aperture is prolonged forward into an oval tube, with its greatest diameter coinciding with the length of the shell. The dorsal aperture is destroyed in all the specimens.

The air chambers are regular and deeply concave. The sutures form ventral and dorsal saddles and broad lateral lobes.

The siphon is comparatively small, moniliform, situated close to the ventral side. Test and surface unknown.

The type specimen figured above measures:—dorsi-ventral diameter of the smallest air chamber 52 mm., dorsi-ventral diameter of last septum 105 mm., dorsi-ventral diameter of the region of the aperture 140 mm. This species is distinguished from *G. ellipticum* by the outer chamber being higher than wide, and in having a more decided curvature.

Comparing *G. angustum* and *G. ellipticum* with *G. linearis*, we have a series in size, comparative height and length of living chamber, and concavity of the septa. *G. linearis* is the smallest, the living chamber is relatively lowest and the sutures are straight, *G. ellipticum* stands intermediate in these respects and *G. angustum* is largest, has greatest relative vertical height of living chamber, and greatest convexity of septa.

Locality.—Wabash City, Indiana.

GOMPHOCERAS PROJECTUM n. sp.

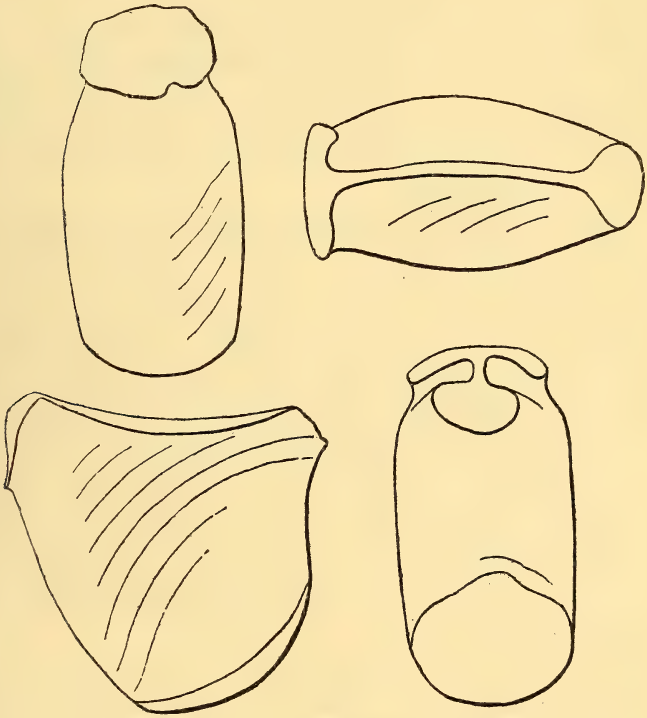
Compare *Gomphoceras* (*Phragmoceras*) *parvum* H. & W., Pal. Ohio, II, p. 151, pl. 8, fig. 10.

Compare *Gomphoceras* (*Phragmoceras*) *nestor* Hall, 20th Rept. State Cab. N. Y., rev. ed., p. 405.

Compare *Gomphoceras* (*Phragmoceras*) *labiosum* Barrande, Syst. Sil., II, p. 218, pl. 50.

Shell small, flattened, and strongly arcuate; in transverse section elliptical.

The living chamber in cross section is narrowly ovoid. The dorsi-ventral diameter increases rapidly upward toward the apertures but the lateral diameter increases slowly. The ventral side is subangular and slightly concave, while the dorsal is rounded and convex. The septum forming the bottom of the living chamber, and the flattened region of the apertures are strongly inclined toward each other, causing the ventral side of the chamber to be very short. The length from this septum to the lower side of the ventral aperture is but a trifle over one-half the distance from the septum to the lower part of the dorsal aperture; also the dorsi-ventral diameter of the shell at this septum equals the latter measurement.



Dorsal view. Aperture.
Lateral view. Ventral view.

The edges of the aperture are abruptly turned inward leaving a narrow slit connecting the dorsal and ventral openings. From the lateral view this flattened top of the shell is seen to be concave. The slit opens forward into the ventral tube-like aperture which is partly broken. The portion of the shell enclosing the dorsal opening extends upward so that the aperture faces toward the rear, and is surrounded by a flaring collar. On one side of the lower edge of this, there is a slight indentation indicating that this aperture may have been lobed.

The air chambers are unknown. The sutures, as shown by the base of the living chamber, have sharp, ventral saddles, broad, low, dorsal saddles and wide lateral lobes.

The siphon, test, and surface markings are not preserved.

The type specimen above figured is undoubtedly peculiar in the unsymmetrical form of the aperture. The long narrow slit, instead of being median, has a decided curve to one side of the centre, which, evidently from the symmetry of the rest of the figure, cannot be due to compression.

Fine striations can be seen on portions of the cast. The course of these striations is indicated in a general way by the oblique lines on the figures.

The dimensions are as follows: dorsi-ventral diameter of the last septum, that forming base of the living chamber, is 30 mm.; diameter just below the apertures 40 mm.; lateral diameter on this section 23 mm.; height along the vertical central axis 37 mm.

G. parvum H. & W. is smaller, and possibly may be the young of the same species. The region in front of the dorsal opening apparently does not rise as in *G. projectum* making the top of the latter somewhat concave in lateral view. Also the curve of the shell under the ventral tube in *G. projectum* is more gentle than in *G. parvum*. *G. nestor* Hall differs in the dorsal opening facing upward and not to the rear.

G. labiosum Barr. has a smaller ventral opening, and greater lateral diameter of the living chamber, also the distance from the ventral opening to the last septum is proportionally greater.

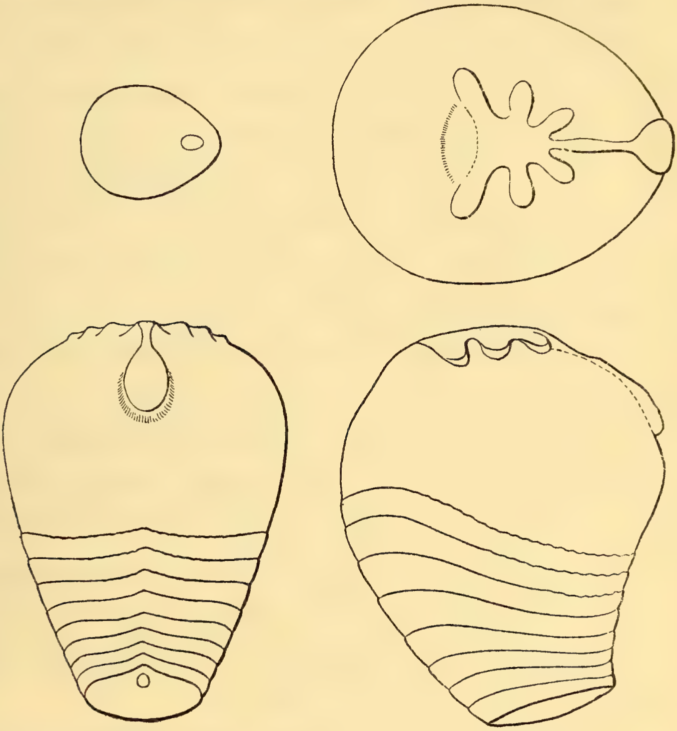
Locality.—Delphi, Indiana.

GENUS HEXAMEROCERAS Hyatt.

This genus includes Silurian species of Gomphoceratidæ which have the dorsal aperture constricted in such a manner as to leave six lateral sinuses, arranged in three pairs symmetrically as to dorsi-ventral plane of the animal.

The type is *Hex.* (*Phrag.*) *panderi* Barrande (Syst. Sil. II, plate 48).[1]

HEXAMEROCERAS DELPHICOLUM n. sp.



Smallest septum. Aperture.
Ventral view. Lateral view.

Compare *Hexameroceras* (*Phragmoceras*) *callistoma* Barr., Syst. Sil. II, p. 234, pl. 47 and 67.

Compare *Hexameroceras* (*Cyrtoceras*) *Hertzeri* H. & W., Pal. Ohio, II, p. 150, pl. 8, figs. 7 and 8.

Shell small, arcuate, rapidly enlarging, transverse section broadly ovate; apex unknown.

Living chamber is short, its height being two-thirds the greatest dorsi-ventral diameter, the lateral diameter is about nine-tenths of the dorsi-ventral. In general outline the living chamber increases slowly in breadth and width from the last septum up for about 10 mm., then decreases equally on all sides to the constricted apertures, forming an oval dome. It was probably half as long as the whole shell (restored) and its contents must have been greater than all the rest of the shell combined. On the base are a series of crenulations somewhat indistinct.

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[1] See. Proc. B. S. N. H., XXII, p. 278.

The dorsal opening of the living chamber consists of six lobes arranged symmetrically, three on each side of a median-dorsi-ventral-line, and radiating from a centre which coincides closely with the vertical axis of the chamber. The dorsal pair of lobes is the largest, the median lobes are shorter and the third pair of lobes, those toward the ventral opening, is the smallest and nearest together. A narrow slit about 1 mm. in width and 12 mm. long connects these lobes with the single ventral opening. On this slit there is a slight thickening, looking like the beginning of a fourth pair of lobes.

The ventral opening is ovate and is surrounded on all sides, excepting where it joins the narrow slit, by a shallow sinus. The general appearance of the whole dorsal opening is that of a triangle pointing downward; from its apex a median line runs forward and terminates in an oval, the ventral opening.

The septa are slightly concave with very broad low dorsal saddle and narrow ventral saddle on the sharp angle. The smallest septa are near together, about 1 mm. apart, and above these the closed chambers increase regularly in height to the third from the last, then decrease slightly to the last chamber.

The sutures show the crenulations continuous with those of the bottom of the living chamber so that a large part of the surface shows faint vertical flutings, not represented in the illustration.

The siphon is ventral, 1 mm. in diameter and slightly elliptical. It is shown only on the smallest septum, at which place it is 3 mm. from the ventral angle. In the figure of this septum, shown above, the siphon is proportionally too large.

The test and surface markings are not known.

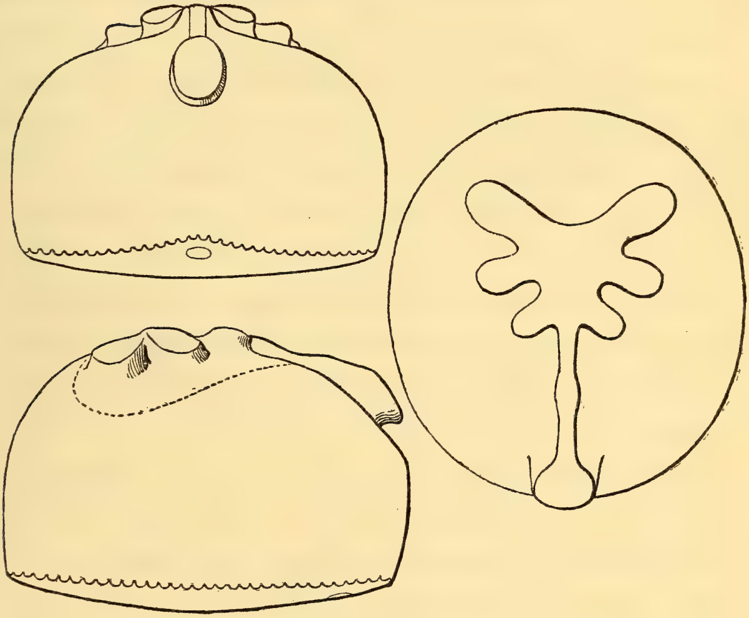
This species is represented by a single interior cast figured in full size above. The dimensions of this cast are :—dorsi-ventral diameter of living chamber 41 mm., greatest lateral diameter 37 mm., height of living chamber along central axis, 23 mm.

This species resembles *H. callistoma* and the discovery of other specimens may prove this to be an American variety. It differs in the greater curvature, more rapid expansion of the shell and greater breadth of living chamber near the aperture.

H. Hertzerii H. & W. is flattened in the region of the ventral opening, and the dorsal aperture is not so clearly developed into distinct lobes.

Locality.—Delphi, Ind.

HEXAMEROCERAS CACABIFORMIS n. sp.



Ventral view
Lateral view.
Aperture.

Shell of medium size, straight; transverse section subcircular; closed chambers and test unknown.

The living chamber is short, its height along the vertical axis being a little less than three-fourths the greatest diameter. On the edges of the last septum are crenulations. (In the figures above, these are somewhat too small and regular.) The shell increases but slightly in diameter above the base of the living chamber excepting on the ventral side where it swells out below the ventral aperture. The greatest dorsi-ventral and lateral diameters are on a plane about 10 mm. above the base. From this point the shell decreases in size gradually and then rapidly rounds over to the apertures.

The apertures are very like those of *H. delphicolum* but are proportionally a trifle wider.

The six dorsal lobes rise above the surface of the cast, showing that they were prolonged upward by the shell, forming six short tubes or funnels. The dorsal pair have a decided inclination toward the rear.

The ventral aperture is prolonged into a tube projecting forward and partially surrounded by a deep sinus. The septa as shown by the base of the living chamber are but slightly concave. The sutures are nearly straight with a low ventral saddle. The siphon, as shown on the base of the living chamber, is slightly elliptical, and in the type specimen is 4 mm. in diameter and 5 mm. from the ventral side. The surface markings are unknown.

The several diameters of the type specimen are: dorsi-ventral 50 mm., lateral 46 mm., vertical 34 mm. A larger, less perfectly preserved cast is nearly twice these measurements.

Professor Hall has described (20th. Rept. State Cab. N. Y., p. 410) a cast under the name of *Gomphoceras septoris* which in general shape is similar to this species. The possession of a seventh dorsal lobe puts this, however, in the genus Septameroceras (Hyatt).

Locality.—Delphi, Ind.

Similar to the above described type are several compressed and distorted specimens from Wabash City. These consist of larger casts of the living chamber and several closed chambers, compressed laterally, poorly preserved and worn, yet in one case showing the characteristic outline of the aperture and the shape of the living chamber. Several of the smallest closed chambers are missing, but enough remain to show that the shell increases rapidly in size and is nearly straight, the dorsal side being slightly more convex than the ventral. The general form is compressed, ventricose and turbinate. The living chamber is about one-half the length of the whole shell and its bulk from its turbinate form must have been two or three times that of all the closed chambers together. The greatest diameter of the best preserved of these casts ranges from 80 to 100 mm.

The septa are strongly concave from compression, and average 7 mm. apart.

The siphon is not determined, and the test is unknown.

The general shape of these casts resembles the figure of *G. Eos* Hall, Pal. Ohio, II, pl. 3.

GENUS PENTAMEROCERAS Hyatt.

This genus differs from Hexameroceras in having but five sinuses forming the dorsal aperture. The two pairs of lateral sinuses are arranged symmetrically, as in Hexameroceras, while the fifth sinus is dorsal and occupies a median position, being bisected by the dorsi-ventral plane of symmetry.

PENTAMEROCERAS MIRUM Barrande.

Gomphoceras mirum Barrande, Syst. Sil. Bohême, II, p. 319, pls. 82 and 91.

This very small species is represented by several casts of the living chamber with a number of closed chambers attached and without the shell. In size and general shape it resembles a conical bullet, from which appearance the quarrymen call these fossils "minieballs."

Comparing these specimens with Barrande's figures on plate 82 (above cited) they are seen to agree very closely in size and general outline. The dorsal side is not as flat nor is the ventral side as round as in the specimens figured, the horizontal sections being more nearly circular. In this respect these Indiana specimens stand intermediate between the specimens represented on plate 82 and those on plate 91. The last are elliptical in the dorsi-ventral direction.

The apertures are somewhat obscure but do not differ essentially, if at all, from those figured on plate 82.

The siphon is also similar in size and position, being a mere dot against the ventral side of the shell.

The septa adjacent to the living chamber are nearer together than those below, indicating as Barrande has pointed out, that these little forms are probably adults. The surface of the shell is not shown.

Locality.—Delphi, Ind.

ASCOCERATIDÆ.

GENUS ASCOCERAS Barrande.

Ascoceras includes species having a wide aperture, and is thus distinguished from the other Ascoceratidæ, which like this have the peculiarly curved compartments placed nearly parallel to the long axis of the shell.

It includes two groups: one with annulated shells, the other with smooth banded or striated shells.[1]

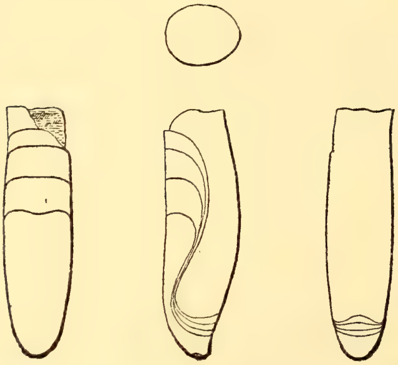
Ascoceras Newberryi Billings.

Ascoceras Newberryi Billings, Pal. Foss., I, p. 163.

To this species is referred a small poorly preserved specimen without shell and with one faint marking indicating a suture. The upper part is broken so that the aperture is not shown. In general outline this short and ventricose cast resembles the figure and description given by Billings of the type from the Middle Silurian of Anticosti.

Locality.—Delphi, Ind.

Ascoceras Indianensis n. sp.



Dorsal. Lateral. Ventral.

Shell very small, nearly straight, slender, transverse section broadly oval; greatest diameter one-third the distance from the apex to the most remote portion of last septum.

The side on which is the living chamber — the ventral side — is convex and the dorsal side is slightly concave giving the shell the appearance of being slightly curved toward the dorsal side.

In the horizontal section, through the middle of the fossil, the dorsi-ventral diameter is 9½ mm.; lateral diameter at the same place is 8 mm. The narrower end of the oval is on the ventral or convex side. Horizontal sections, taken in succession below the centre, become more and more nearly circular as they are taken lower down until, at the place where the septa cross the ventral side, the section is circular. Below this place the section becomes slightly elliptical, the greatest diameter being lateral or at right angles to the greatest diameter above. The extreme tip bearing the mark of the pseudo-siphon turns slightly towards the ventral side.

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[1] Proc. B. S. N. H., XXII, 1883, p. 279.

The living chamber occupies about one-half of the broken shell. On the portion just above the upper limit of the sutures, the living chamber appears to be very slightly constricted, forming a neck, which enlarges again slightly toward the aperture.

Of the closed chambers, the upper one, that adjacent to the living chamber, is the narrowest. On the ventral view the four sutures are seen crossing the figure at a point 3 to 5 mm. above the extreme point. The first suture curves slightly downward forming a shallow lobe, the second runs nearly horizontal, while the third and fourth curve upward forming slight ventral saddles. On this view the sutures are less than one millimeter apart. Looking at the specimen from the side, the sutures are seen to curve backward and upward approaching each other, then run nearly together, sweeping in a gentle curve up and forward toward the ventral side, then separately turn off towards the back, crossing the back. On the dorsal view the lowest suture shows a very slight inflection or dorsal lobe, while the second suture crossing 4½ mm. above is nearly straight. The third suture is 3½ mm. above the second and the fourth 2 mm. above the third, each having a broad, low, dorsal saddle. The greatest length of the lowest enclosure is 18 mm.

On the extreme tip are a small dot and circular cicatrix about 1½ mm. in diameter.

Locality.—Limestones at Delphi, Indiana.

In addition to the above described fossils the following species have been identified:

Lituites Bickmoreanus Whitfield, Bull. Am. Mus. Nat. Hist., I, No. 6 (a very common form at Wabash, Ind.).

Lituites Graftonensis Meek and Worthen, Geol. Ill., VI, p. 507, pl. 25, fig. 1 (from Wabash, Ind.).

Lituites multicostatus (?) Whitfield, Geol. Wisc., IV, p. 303, pl. XX, fig. 7 (fragments from Wabash, Ind.).

Trochoceras Desplainense McChesney, Trans. Chicago Acad. Sci., I, p. 52, pl. VIII, fig. 1 (Niagara limestones east of Wabash, Ind.).

Prof. Hyatt pointed out the characteristics of some of the specimens exhibited by Mr. Newell.

The question of meeting on the evenings in February and March, set for the lectures in aid of the Biological Laboratory, was discussed, but no action was taken.

GENERAL MEETING, FEB. 1, 1888.

The President, Prof. F. W. PUTNAM, in the chair.

The President announced that two days ago the great botanist, whose name had been on the roll of the Society for half a century, passed from our circle.

Professor Asa Gray joined the Society in 1837; and in 1842, at the age of 32 years, was made an Honorary Member. This same year he accepted the Fisher Professorship of Natural History at Harvard, and was the first and the last of the trio of great naturalists who made Harvard College famous as a school of natural history a generation ago.

The first of the three to be called from his labors was the enthusiastic and inspiring Agassiz, the zoologist and geologist, born in 1807. He came to the college in 1847, and died in 1873 at the age of 66.

The second was the patient and painstaking Wyman, the comparative anatomist and anthropologist, born in 1814, and made a professor at the college the same year with Agassiz, whom he survived hardly a year, dying in 1874 at the age of 60.

And now we have to mourn the conscientious, hardworking botanist, who was born in 1810, became a professor at Harvard in 1842, and died on Jan. 30, 1888, at the age of 78.

It is of interest that all three of these great men were students of medicine at nearly the same time, Agassiz taking his degree in

1830, Gray in 1831, and Wyman in 1837, and that they never practised medicine, but entered the fields of research and teaching. The influence of these men has been widely felt and to them can be largely attributed the great advance made in natural history in this country by the last generation. While many other distinguished workers have taken part in our Society and have added to its fame, and others will come forward in the future, who may become equally distinguished, these three men will be ever held in the highest esteem for their inspiring work and for the great influence which they exerted as teachers.

At the next meeting of the Society a biographical notice of Professor Gray will be read by Professor Goodale. After the reading of the records this evening it will be in order to take such action as may seem proper in respect to one whose memory we shall always love to honor.

After the records had been read, Professor Hyatt moved that, out of respect to the memory of Professor Gray, our late eminent associate, the Society do now adjourn, which was unanimously voted, and the President declared the meeting dissolved.

General Meeting, Feb. 15, 1888.

The President, Prof. F. W. Putnam, in the chair.

Prof. G. L. Goodale read a sketch of the life and work of Dr. Asa Gray. This sketch will be published in the proceedings of the Society at some future time.

Prof. W. G. Farlow offered the following resolutions:

Resolved: That in the death of Asa Gray this Society mourns the loss of a most honored member and efficient officer; one whose presence for many years lent a charm and gave zest to its meetings; whose scientific studies have enriched the pages of its publications; whose counsel was always as freely given as it was eagerly sought; and whose example will continue to be, as it always has been, an encouragement, an inspiration.

Resolved: That we recognize the great loss to American Science in the death of one who was both a great scientific authority and a popular teacher, in whom a deep insight into the workings of nature and an exceptional capacity for the highest scientific work were combined with a rare talent for generalization and a most winning simplicity and attractiveness of manner.

Resolved: That as members of this Society we recall with sadness, but not without a sense of mournful pleasure, his many amiable and noble personal qualities which endeared him to us individually and we would extend our cordial sympathy to his bereaved family in their great affliction.

Professor Hyatt seconded the resolutions and they were unanimously adopted by the Society by a rising vote.

General Meeting, March 7, 1888.

The President, Prof. F. W. Putnam, in the chair.

A letter from Mrs. Asa Gray, thanking the Society for the resolutions of sympathy adopted at the last meeting, was read.

The following paper was then presented:

GEOLOGY OF THE BLACK HILLS OF DAKOTA.

BY W. O. CROSBY.

Introduction.

The first systematic examination of the geology of the Black Hills was made, by the lamented Prof. Henry Newton, under the auspices of the United States Geological Survey, in the summer of 1875, before the Hills were opened to civilization. His report, which was not published until 1880, three years after the author's death, is, considering the great difficulties under which he labored, wonderfully comprehensive and accurate. Although the dozen years which have elapsed since Newton's survey have witnessed the rapid settlement of the Black Hills and the development of the mineral resources of the district, they have added very little to our knowledge of the geological structure of the Hills. Newton's memoir still stands essentially intact; and, although such of my observations and conclusions as seem to contravene his work must necessarily be given special prominence in this paper, it should be understood that these are insignificant compared with those which fully sustain his report.

For a general view of the geological structure of the Black Hills we may refer to Newton's introductory chapter:—"Around a nucleal area of metamorphic slates and schists, containing masses of granite, the various members of the sedimentary series of rocks, the Potsdam, Carboniferous, Trias or Red Beds, Jura, Cretaceous and Tertiary, lie in rudely concentric belts or zones of varying width, dipping on all sides away from the elevatory axis or region of the Hills. From the Hills outward the inclination of the beds gradually diminishes until all evidence of the elevation is lost in the usual rolling configuration of the plains. At numerous points, also, within the area of the Hills are centres of volcanic eruption."

That the Black Hills, as here indicated, offer an exceptionally fine field to the geologist is the concurrent testimony of all who have visited the region. The late Dr. Hayden said that, "in all the western country I have never seen the Cretaceous, Jurassic, Triassic or Red Beds, the Carboniferous and Potsdam rocks, so well exposed for study as around the Black Hills." Elevated as they are like an island above the surrounding sea of the plains, and separated by more than one hundred miles from the nearest spur or sub-range of the Rocky Mountains, the Black Hills are a complete study in themselves. Exhibiting in the strata exposed, and in the general character of the elevation, most of the principal features of the geology of the Rocky Mountains, they are a geological epitome of the neighboring portions of that great range. The geologist, therefore, finds in this region a monographic study of universal interest, and by the regularity of the uplift, by the absence of great faults in the strata, and by the splendid exposures of the sedimentary rocks, he is given a piece of mountain geology of great beauty, simplicity, and ease of elucidation (Newton).

The Archæan or metamorphic rocks of the Black Hills occupy the axial or nucleal area of the uplift, and are exposed almost continuously over a tract about sixty miles long north and south, and twenty-five miles in its greatest width east and west. Made up as it is of many alternations of slate, quartzite, schist and granite, *i. e.*, of rocks varying greatly and abruptly in hardness and durability, this area has developed, under the discriminating erosion of the atmospheric agents and running water, and in the apparently complete absence of the levelling action of glaciation, a singularly rough and mountainous topography, which culminates in the granitic region about Harney Peak.

The margin of the Archæan area is bordered continuously by an escarpment more or less abrupt, and usually several hundred feet high, formed of the Potsdam sandstone and the Carboniferous limestones. This escarpment faces inward or toward the Archæan area, and in the cañons which cut into it the slates and schists are seen beneath the sandstone of the Potsdam which rests unconformably upon them. With the exception of Harney and a few of the neighboring peaks, the average elevation of the schist and slate area is considerably below that of the encompassing sedimentary rocks (Newton).

Although the streams in the Archæan area have in many cases sunk their channels below the base of the Potsdam, yet the general level of the intervening ridges is fully as high as, and often higher than, that geological horizon. Hence, since it is certain that the Potsdam formerly covered a large part, and the Carboniferous the whole, of the present Archæan surface, which is being steadily enlarged by the recession of the encircling Potsdam-Carboniferous escarpment, I cannot follow Newton in ascribing the fact that the receding edge of the Carboniferous limestone overlooks the Archæan surface to the superior hardness of the limestone. The difference in level of the two topographies is mainly due to the fact that the normal position of the Paleozoic rocks is topographically, as well as geologically, above the Archæan.

ARCHÆAN FORMATIONS.

Newton has divided the Archæan rocks of the Black Hills into two groups — a western, more crystalline and probably older group composed chiefly of schists; and an eastern, less crystalline and probably newer group composed chiefly of slates. The boundary between the two groups appears to be quite sharply defined, and is probably indicated with substantial accuracy on Newton's map. But no sections have yet been studied which exhibit clearly the stratigraphic relations of the two groups. The greater age of the western group is inferred, however, from its more crystalline character, and from the fact that the granitic masses about Harney Peak, although traversing the western series of schists up to the very boundary of the eastern series, have not been observed to cross that boundary in any case. I may add, as the result of my own observations, that the occurrence in the conglomerate of the eastern series of pebbles which have quite certainly been derived from the harder rocks of the western series seems to leave little room for doubt as to the relative ages of the two formations.

Older or Western Series.

Mica schist is the prevailing and most characteristic rock of the western or older series. Although subject to great variations in character, it is in the main a gray and finely, but distinctly, crystalline rock. Garnet is the chief accessory mineral, and very frequently, especially in the western part of the area, it is so highly charged with garnets that it acquires a dark reddish color. The garnets are well crystallized, but of small size, rarely exceeding a quarter of an inch in diameter. The typical mica schist sometimes changes to a distinct hydromica schist, which is also often highly garnetiferous. It also passes imperceptibly into highly siliceous or quartzose varieties containing but little mica, and from these into a hard, tough quartzite, which is usually slightly micaceous, varies from white to a light or dark gray color, and is bright and glassy on the conchoidal fracture. The mica schists also pass occasionally into chlorite schist and hornblende schist and less rarely into gneiss. The gneiss, which is always highly micaceous, is found chiefly in the granitic district about Harney Peak; but it is not a prominent rock even there. The mica schists are traversed conformably with the stratification by many rather small veins of quartz, which have usually a swelling or lenticular form.

The granites of the Black Hills occur, as already mentioned, only in the schists and gneiss of the western series. They are found over a large area entirely in the southern portion of the Archæan district. All of the granite masses which have been examined are parallel with the stratification of the schistose rocks; and when their structure is discernible they are seen to be, like the quartz veins, lenticular in shape.

Concerning the stratigraphy of the western series, much remains to be determined. It is quite plain, however, that in a general way at least the strike of the schists curves around the granitic and gneissic area, and that the normal dip of the strata is away from this nucleal mass at very high angles.

Newer or Eastern Series.

The eastern or slate series occupies probably a larger portion of the Archæan area than do the schists of the western series. Its predominant rocks are distinguished by their fine and uniform slaty texture. Perhaps the most important type is a fine grained, variously colored clay slate or argillite, which usually splits readily parallel with the bedding. This is often lustrous on the flat surfaces or perceptibly hydromicaceous, and frequently passes insensibly into a distinct phyllite or argillaceous schist, and even into a true hydromica schist. The slates also pass into harder, siliceous varieties; and these often become distinctly arenaceous, changing to quartzite, which is one of the most prominent and characteristic rocks of this series. It resembles the quartzite of the western series, but is much more abundant, occurring in beds from 50 to 500 feet in thickness. In both series the erosion of the soft schists and slates leaves the quartzites in bold and ragged relief, huge dyke-like ledges trending across the country for miles, now bristling suddenly in peaks, and again outcropping in the cañons of the creeks as sharply defined walls (Newton).

The quartzite usually contains some hydromica and, like the slates, passes into hydromica schist. It also becomes coarser in some localities, passing into coarse grits and conglomerate, which have, in the aggregate, a very large development. The pebbles of the conglomerate have suffered extensive deformation by compression, and the whole rock is highly metamorphic. The rocks of this series, including the slates, schists, quartzites and conglomerate, are sometimes highly ferruginous; the iron occurring chiefly in the form of specular hematite. On Box Elder Creek, a ridge some 400 feet in height is composed largely of this crystalline siliceous hematite. Occasional bands of almost pure specular hematite several inches in thickness are found in the mass, but the rock is as a whole so highly siliceous as to be entirely useless as an iron ore. In some cases the hematite is so regularly interlaminated with the slates and quartzites as to recall the siliceous banded hematite of the Lake Superior region. On the other hand, the ferruginous schists are often typical itabarite, specular and micaceous hematite taking the place of mica in the rock.

The eastern series is also traversed by numerous veins of quartz, which usually coincide with the bedding in the more schistose rocks, but are quite independent of it in the quartzites and other massive varieties. They lack, in a large measure, the swelling or lenticular form of the veins in the western series. The dip of the strata of the eastern series is always high, 70° to 90°, and usually westerly.

It is not practicable, with the data now at hand, to determine even approximately, the extent of the plication, or the thickness, of either the eastern or western series. Newton has shown that the quartzites of the eastern series are found chiefly in two belts along its eastern and western margins, an arrangement which suggests a single gigantic fold. This structure would, however, give the series an almost incredible thickness.

The preceding descriptions of the Archæan or metamorphic groups are condensed, sometimes without change of language, from Newton's more complete account, which, so far as the writer's observations extend, is substantially accurate, except that he entirely overlooked the conglomerates of the eastern series. This omission is the more difficult to understand, since the conglomerate is a very prominent rock in several parts of the Hills, and since it is certain that Newton examined the ridges on Box Elder Creek and elsewhere in which it has its best development. I can only conjecture that, in consequence of the extreme metamorphism of the conglomerate, he failed to recognize its true nature, missing, perhaps, the ledges in which the conglomerate structure is most plainly exhibited. Among the localities affording the finest exposures of the conglomerate are the hills above the village of Laflin ; and the ridge on the north side of the road to Galena, about two miles from Laflin. This ridge, which is on Box Elder Creek, is probably the one designated by Newton as affording exceptionally fine exposures of the ferruginous strata.

Although the granitic rocks of the western or older series do not penetrate the newer series, the latter is not probably devoid of eruptive masses. In various parts, but particularly along the middle of the area occupied by the eastern series, there are numerous beds or masses of a dark colored crystalline rock which appears to be chiefly composed of plagioclase feldspar and hornblende and has been provisionally called diorite. So far as observed, the masses of this rock are parallel with the bedding of the schists and slates. But although they are also often distinctly schistose or fissile, they are usually as massive and devoid of bedding lines as any eruptive rock; and it seems necessary to regard them as mainly, if not wholly, intrusive in the slates and schists.

The Metamorphic Conglomerate.

The metamorphic conglomerate and the closely associated argillites, schists and quartzites are, except in their highly ferruginous character, strikingly similar to the metamorphic sediments occurring in Bellingham, Massachusetts.[1] I may, therefore, for the sake of brevity, refer to the published descriptions of the Bellingham rocks for the structural details of the Black Hills series. In both localities it is perfectly plain: (1) That the metamorphic series consisted originally of interstratified beds of ordinary mechanical sediments — slate, sandstone and conglomerate; (2) that the metamorphic agents have not only accomplished the important chemical change implied in the fact that these rocks are now in the main, distinctly hydromicaceous, but also a very marked mechanical change, which is most apparent in the deformation of the pebbles of the conglomerate. The original slates have become fissile argillites or phyllites; the argillaceous sandstones are now mainly hydromica schists; and the coarser sandstones, or conglomerates, approximate to the same metamorphic type, being highly micaceous and, through the elongation of the pebbles, often distinctly schistose; while the pure siliceous sandstones have become quartzites.

The fragmental nature of the conglomerate and the deformation of the pebbles are, in both regions, indisputable facts; and in the Black Hills, as in Bellingham, the deformation is essentially or mainly cylindrical, each pebble being elongated or drawn out rather than flattened. The cross section of the structure shows usually the appearance of a normal conglomerate; while in the side or longitudinal view this is almost entirely wanting, and we see only a regular lamination or schistosity. An occasional pebble has, however, successfully resisted the deformation; and the adjacent pebbles and the micaceous cement are wrapped around it in a very instructive manner. The degree of metamorphism is not uniform, but I have observed in the same mass, or group of ledges, a gradation from a puddingstone showing but little alteration to a finely laminated schist which, considered by itself, shows but slight traces of its conglomerate origin.

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[1] Proc. Boston Soc. Nat. Hist., XX, pp. 373-378. Occas. papers Boston Soc. Nat. Hist. III, pp. 145-153.

The pebbles of the conglomerate are chiefly vitreous quartz, quartzite and siliceous schists, derived, apparently, from the older Archæan series; and the quartzite pebbles largely predominate. The pebbles of vitreous quartz appear to have very generally escaped distortion; and I have been unable to discover any evidence, either in the Black Hills or Massachusetts, that the individual grains of quartz composing the quartzite pebbles are flattened or lengthened; but the deformation of these pebbles appears to be accomplished by the slipping of the grains of quartz over each other. We may conceive that under the enormous pressure the grains in the quartzite behave somewhat as in loose sand, and experience differential movements or flowing.

A careful examination of the conglomerate in all its aspects shows that it has suffered powerful compression in two directions, which, in the Black Hills, are usually approximately horizontal, the pressure perpendicular to the bedding usually predominating. The pebbles and paste have thus been extended or squeezed out mainly in the third direction, which is usually approximately vertical. The general result of this linear deformation of the pebbles is to give the rock a structure which is rather more properly columnar than schistose; and in tracing this mode of metamorphism from the coarser to the finer grained rocks of this sedimentary series, it is found to afford an adequate explanation of a structural feature of the Archæan quartzites which has greatly puzzled many observers in the Black Hills.

The Archæan quartzites are very generally characterized by a curious rectilinear and vertical streaking or columnar structure, which suggests bedding lines at the first glance, but on closer examination often bears some resemblance to the Scolithus borings of the Potsdam quartzite or the stylolite structure often seen in massive limestones. A careful study shows that the streaking usually affects the entire body of the rock, although it has often been locally emphasized through the development of hydromica and other secondary minerals. These marks are doubtless somewhat akin to stylolites in their origin. Although the component grains of the quartzite have not probably suffered extensive deformation, it is impossible to resist the conclusion that the rock as a whole must have yielded, through the gliding of its grains over each other, to the enormous pressure which wrought such a radical change in the structure of the associated conglomerate. The quartzite has, like the conglomerate, been reduced horizontally and squeezed out vertically. In the absence, however, of compressible pebbles or grains and of material from which hydromica might be abundantly formed, it has failed to develop the coarsely schistose structure of the conglomerate or the finely fissile structure or slaty cleavage of the argillites and phyllites; but the extent and direction of the differential movements of its grains are simply indicated by this rectilinear streaking. It is interesting to observe also that a similar longitudinal gliding is often indicated in the argillites by parallel vertical striæ or corrugations on the cleavage surfaces.

Correlation of the Archœan Formations.

Mr. Newton has discussed at some length the question of the geological age of the western and eastern series. He carefully compared them with the Laurentian and Huronian systems respectively, only to find that, while the eastern series bears some resemblance to the Huronian, the western or older series is wholly unlike the Laurentian, and that in neither case do the facts justify even a provisional correlation. That the metamorphic rocks of the Black Hills are truly Archæan, and were fully metamorphosed before the dawn of Potsdam time, is proved by the Potsdam resting upon their upturned edges unconformably, and carrying in the conglomerate at its base fragments of slates, schists, quartzites, etc., of a character precisely similar to that of the underlying rocks.

The writer's observations very soon convinced him, however, that Mr. Newton ought to have looked to New England, rather than to Canada, for the equivalents of the Archæan strata of the Black Hills. Although we may not, before the older rocks of the west have been more thoroughly studied and described, insist upon their exact chronologic correspondence with any formations in the east, there can be no question that both the older and newer series recognized below the Potsdam in the Black Hills are, lithologically, almost identical with two of the prevailing systems of metamorphic rocks in the eastern United States and especially in New England.

The newer series of slates, phyllites, hydromica schists and quartzites agrees very closely with the Taconian system of western New England. In fact, so far as the rocks named are concerned, the correspondence may be described as exact. The conglomerate is, perhaps, more prominent than in the typical Taconian; but scarcely more so than in the series of semi-crystalline rocks of Trinidad and the Spanish Main, which the writer has elsewhere correlated with the Taconian. The specular schists and slates of the Black Hills are matched exactly by the itabarite, which is such an interesting lithological feature of the Taconian in South Carolina and in South America. The most important discrepancy noticed between the newer metamorphic series of the Black Hills and the Taconian system is the absence of crystalline limestones or marbles in the former. We have some evidence, however, that this discrepancy is not real. It is necessary to remember that only a part, perhaps a small part, of these metamorphic terranes is exposed in the Black Hills. To the north and east the ancient eroded surface of the newer series is covered by the Potsdam and higher formations, perhaps for hundreds of miles. That the still concealed portions of this series do include some limestones seems to be placed beyond reasonable doubt by the following observations: In the quite widely separated cañons of Spring Creek and Bear Butte Creek, which flow eastward from the newer Archæan series through the overlying formations, I found that portions of the conglomerate forming the base of the Potsdam contain numerous waterworn pebbles of a finely crystalline white or grayish-white limestone. No strata from which these pebbles could have been derived are exposed anywhere in the Black Hills; and the natural inference seems to be that the pebbles represent beds of limestone intercalated with the slates and quartzites, which are the source of the remaining pebbles of the Potsdam conglomerate, but which are still covered by the Potsdam and other Palæozoic strata.

I am aware that investigations now in progress threaten, as it were, to discontinue the original Taconian system as an Archæan terrane. But this result, even if finally established, cannot invalidate the lithologic correlation proposed here; although it would necessarily deprive it of much of its geological significance.

The western or older Archæan series of the Black Hills cannot be distinguished lithologically from a considerable part of the great series of mica schists and micaceous gneisses forming so large a part of the surface of New England and of the states southward along the Appalachian crystalline belt and which Dr. Hunt has called the White Mountain or Montalban system. The fact that many characteristic Montalban rocks have not been observed in the Black Hills does not invalidate this correlation. For this older Archæan series of the Hills exhibits no types or varieties not belonging to the Montalban of the east; and it is not less diversified lithologically than equally large or larger areas of Montalban in different parts of New England. In many ways it reminded me strongly of the crystalline region between the Connecticut River and the Berkshire valley, in Massachusetts.

Origin and Age of the Granite.

Perhaps the most characteristic Montalban rock in the Black Hills is the granite. Although Newton has given us a satisfactory account of the composition and texture of this rock, he has evidently, in regarding it as eruptive, fallen into a serious error concerning its origin and its relations to the enclosing schists. His description and map appear to be at fault, also, in giving the impression that the granite is continuous over areas several miles in extent. As already explained, the granite culminates in Harney Peak and the mass of mountains of which it is the summit. I ascended Harney Peak, and skirted the northern and eastern flanks of the Harney Range, for the express purpose of studying the granite and its relations to the schists. To my great surprise, I found no broad or continuous area of granite; but the prevailing rock in all this part of the so-called granitic area is mica schist with some micaceous gneiss. The granite becomes relatively more abundant as we penetrate the mountains; but, so far as observed, it nowhere forms more than one-half of the surface; and it is doubtful if it forms, on the average, as much as one-tenth of the surface of that part of the granitic area which I traversed.

We have already noticed Newton's important observation that the granite occurs wholly, so far as known, in the form of huge lenses parallel with the schists; and his section of Raw Hide Butte, one hundred miles southwest of the Black Hills, which Newton says is composed of granite and schist similar to those of the Black Hills, would serve admirably as an illustration of the structure of almost any part of the Harney Range. The lenses and swelling masses of granite splitting the schists and alternating with them range in thickness from a foot or less, to perhaps five hundred feet. They are often branching and sometimes enclose masses of schist. Being much harder than the schists, the granite masses have been left in high and rugged relief by the agents of erosion. Over an area of many square miles about Harney Peak, the granite rises above the schists from one hundred to five hundred feet in precipitous and even wall-like, craggy ridges, which are transversely cleft to form gigantic saw-teeth or jutting towers and pinnacles, the summits of which are often quite inaccessible. The effect of this topography is not only to make the Harney Range exceedingly difficult to traverse; but also largely to conceal the intervening schists and gneiss beneath the débris of the granite. It may have been this circumstance that led Newton to underestimate the importance of the stratified rocks in this area.

Newton's discussion of the origin of the granite is directed chiefly to showing that it can not be regarded as metamorphic, as having been derived from the associated schists and gneiss, and that it must, therefore, be eruptive. We may, however, readily grant the first conclusion without accepting the second; for it seems not to have occurred to Newton that there is a third alternative. But the following description of the granite, condensed, with only slight verbal changes, from his pages, will, it is believed, suffice to convince every student of the crystalline rocks of New England that the granitic masses of the Black Hills are not essentially unlike the great segregated veins intercalated with our Montalban schists and gneisses, and which are the source in many localities of coarsely crystalline mica, quartz and feldspar for commercial uses.

"The granite of the Black Hills varies but little in character. Its texture is so extremely coarse that it would scarcely be recognized as granite by one accustomed to the fine-grained varieties of New England or the Rocky Mountains. It is granite on a large scale, with all the elements of that rock — feldspar, quartz and mica — present, but instead of their being mixed with tolerable uniformity throughout the mass each constituent is very highly crystalline and aggregated by itself. Feldspar forms 70 or 75 per cent of the rock, and presents large crystal faces and cleavage masses. The quartz is commonly glassy and clear, but many large masses are of a delicate pink or rose color. It composes about 20 per cent of the granite, and often penetrates the feldspar in slender prisms, forming graphic granite. The mica ranges from silvery white to dark brown in color. It is always highly crystallized, and well defined hexagonal crystals two inches in diameter are very common; while mica plates six inches or more across have been found. It forms only about 5 per cent of the granite and is usually found in bunches or segregations. Besides these three minerals, the only one found in abundance is black tourmaline. It sometimes forms 3 or 4 per cent of the granite and is usually highly crystalline. Crystals from three to eight inches in diameter and nearly a foot in length are not very exceptional."

Many of the granite masses exhibit more or less distinctly the banding and the comb structure so characteristic of true segregation veins. In some of the smaller veins, especially, the prisms of tourmaline are arranged with great regularity at right angles to the walls and shoot through successive layers of quartz and feldspar from the walls to the centre of the vein. Besides tourmaline, the granite veins contain columbite and cassiterite; and the numerous tin mines which have been opened in the granitic rocks of the Harney Range have made the determination of the composition, structure and origin of the so-called granite questions of great economic as well as scientific interest. The miners very generally call the gangue of the tin ore *greisen*, although it consists but rarely of quartz and mica alone. At the celebrated Etta mine the cassiterite is found chiefly in a crystalline aggregate of greenish white muscovite and albite (clevelandite) containing but little quartz; yet, on account of carrying the tin ore, this matrix has been called *albitic greisen*. This vein, which is several hundred feet wide and has been traced for a considerable distance, affords, in its truly wonderful mineral developments, a complete refutation of the view that these masses are eruptive. The relatively finely crystalline albite-muscovite gangue of the cassiterite is distributed irregularly among extremely coarse crystallizations of albite, orthoclase and quartz, and gigantic crystals of spodumene. Many of the spodumenes range from five or ten to thirty and even forty feet in length, and from six inches to three feet in breadth, with very perfect terminations.

My own observations and Newton's description alike force me to the conclusion that true eruptive granite is probably entirely wanting in the Black Hills. The facts already cited make it more than probable that this prodigious development of endogenous granite, which appears to die out very gradually as we pass from the centre of the Harney Range outward into higher and higher portions of the great series of schists, was completed before the formation of the eastern or newer Archæan series began; while the occasional occurrence of pebbles of feldspar and rose quartz in the conglomerate, at the base of the Potsdam shows, as Newton has pointed out, that the granite veins, like the enclosing slates and schists, are unquestionably pre-Cambrian. That the Harney granite is older than the newer series of schists is also quite clearly proved by an observation made by my father, F. W. Crosby, in the northern Hills. In the vicinity of the Monarch mine, east of Deadwood, the newer schists are overlain by the Potsdam beds, which are traversed by large intrusive dikes and sheets of porphyry. At some points the porphyry is so crowded with fragments of the rocks which it intersects as to present the aspect of a breccia. It not only encloses the Potsdam quartzite and shale, but fragments of the underlying slates and schists are especially abundant, and an occasional fragment of granite precisely similar to that of the Harney Range is observed. These have certainly been brought up by the lava from some formation or horizon below the newer Archæan series, which, with the exception of the Potsdam, forms the surface for miles in every direction from this point.

Paleozoic and Mesozoic Formations.

The two most salient facts in the stratigraphy of the Black Hills are the perfect unconformity observable everywhere between the Potsdam sandstone and the underlying Archæan schists and slates; and the equally perfect conformity between the Potsdam and the overlying formations. The entire conformity of the Potsdam and Carboniferous is a universal fact, which is clearly exhibited in nearly every cañon and escarpment throughout the length and breadth of the Hills.

Conformable Contact of the Cambrian and Carboniferous.

The conformity of formations which represent essentially continuous deposition, like the Paleozoic series of the Appalachian region, should not excite surprise, even though the oldest and newest strata in the series—the Potsdam and Carboniferous—are separated by an enormous interval of geological time. But the case is different in the Black Hills, for the conformable Potsdam and Carboniferous here are not separated by a great thickness of similarly conformable Ordovician, Silurian and Devonian strata, but the Carboniferous appears to lie directly upon the Potsdam. In other words, the intervening epochs are a complete stratigraphic blank, a lost interval of vast duration.

This conformable contact of the Potsdam and Carboniferous, which would be sufficiently remarkable if limited to the Black Hills, is known to exist over almost the entire Rocky Mountain region. A few of the numerous areas of Paleozoic strata scattered over this vast territory exhibit, between the Potsdam sandstone and the Carboniferous limestones, traces or meagre developments of the Ordovician, Silurian and Devonian formations. But it is difficult or impossible to define the exact horizons of these beds; and continued investigation only establishes more clearly the general fact that few or none of the many distinct periods and epochs between the Potsdam and Carboniferous in the Appalachian region can be recognized in the Rocky Mountains. Farther west, however, in western Utah and Nevada, or toward the western shore of the Paleozoic ocean, the Ordovician, Silurian and Devonian appear to be, in thickness and distinctness, somewhat comparable with the same formations in the east.

Although several slight unconformities have been observed among the Paleozoic beds in the Grand Cañon and Nevada sections, indicating corresponding oscillations of the floor of this part of the Paleozoic ocean, the perfect and widespread conformity of the Potsdam and Carboniferous absolutely forbids the supposition that the western part of the United States was dry land during any considerable part of the intervening epochs of Paleozoic time. The surface of the Potsdam is not eroded, and its strata do not exhibit the disturbance which would almost necessarily have attended the elevation of such a vast expanse of the sea-floor.

The lowest Paleozoic strata of North America rest everywhere unconformably upon an eroded Archæan foundation; and hence few facts in American geology are more firmly established than that the part of this continent subsequently covered by the Paleozoic sea, stretching from the Adirondacks and the Blue Ridge to the Sierra Nevada or beyond, had been dry land for a long period anterior to the general interchange of continental and oceanic conditions which spread the sea over its surface. The Blue Ridge, Adirondacks, and, perhaps, some of the New England Archæan ranges, the Highlands of Canada, the Rocky Mountains, and probably the Sierra Nevada, were then in existence; and the areas of the intervening basins first invaded by the Paleozoic sea must have been in a general way those now covered by the lowest Paleozoic sediments, the Keweenaw or Grand Cañon beds, following the classification of Walcott.

At the close of the Keweenawan age, as Walcott has shown, and during the deposition of the lower and middle Cambrian strata in New England, New Brunswick and Newfoundland, the Keweenawan beds in the Lake Superior and Grand Cañon areas were elevated and extensively eroded, before the deposition upon them of the upper Cambrian or Potsdam strata. The Potsdam was not only spread over the eroded Keweenawan series, but also, as already indicated, over extensive Archæan areas which had not been covered by the Keweenawan sea. The Potsdam thus indicates a more general subsidence of the land than occurred during Keweenawan time; and the Paleozoic ocean may now be regarded as fairly established over the Archæan continent.

The enormous volumes of the Paleozoic sediments in the Alleghany region and in Utah and Nevada, although diminishing in thickness in both cases away from the shore line, conclusively prove (1) that both the eastern and western margins of the Paleozoic sea were areas of a progressive subsidence continuing, with unimportant interruptions, through the whole of Paleozoic time; and (2) that over these marginal areas deposition so nearly kept pace with the subsidence that the comparatively small oscillations of the crust attending the downward movement were sufficient to convert the areas of deposition into areas of erosion, and explain the slight unconformities of the Paleozoic formations already noticed.

That the profound subsidence permitting the accumulation of from six to eight miles of sediments along the ancient shore lines was not limited to the marginal portions of the Paleozoic sea, is proved by the thinness and the largely calcareous nature of the Paleozoic formations in the central areas of the continent, and also, it is believed, by the great hiatus without unconformity between the Potsdam and Carboniferous. The Rocky Mountains were almost completely submerged before the close of the Potsdam period. Although it may be true, as Emmons and others have suggested, that the highest points of the range have been dry land continuously since Archæan times, the nearly universal extension of the great Carboniferous limestone, save where it has been removed by erosion, is alone sufficient to prove that the main mass of the range must have been profoundly submerged. We may well suppose, therefore, that the Rocky Mountains formed a submarine ridge in the Paleozoic sea similar to that which now, along a general north-south line, divides the basin of the Atlantic, the higher points only of both the Paleozoic and the Atlantic submarine ridges projecting above the water in widely separated oceanic islands. That the Rocky mountains did not exist as considerable land areas in the Paleozoic sea is shown clearly enough, also, by the general absence, above the Potsdam, of the mechanical sediments which would necessarily have been formed by their degradation.

Perhaps the most important fact having a distinct geological bearing, which we owe to the dredgings carried on in the deeper portions of the sea, is the extremely slow rate of deposition over the abyssal areas of the ocean floor. The distance from land and the chemical conditions, almost entirely exclude ordinary mechanical and calcareous sediments; and we find, after crossing the calcareous and siliceous oozes, only the impalpable red clay, which is the truly abyssal deposit. The following characteristics of the red clay afford ample evidence, as Sir Wyville Thompson and Mr. John Murray have shown, that it accumulates with almost infinite slowness:—

Over the red clay areas, the dredge brings up large numbers of nodules of the iron and manganese per-oxides. "The nodules are evidently formed in the clay, and the formation of the larger ones and the segregation of the material must have required a very long time; while many of the sharks' teeth forming the nuclei of the nodules belong to species which we have every reason to believe have been extinct since early Tertiary times. Some teeth of a species of Carcharodon are of enormous size, four inches across the base, and are indistinguishable from the huge teeth found in the Eocene beds." On this point Mr. Murray says: "When there has been no reason to suppose that the trawl has sunk more than one or two inches in the clay, we have had in the bag over a hundred sharks' teeth, and between thirty and forty ear-bones of whales."

The time since the Eocene, when the Carcharodons lived, is estimated by geologists at more than a million years, and yet enough clay has not been deposited during this immense period to bury the teeth of this giant shark beyond the reach of the dredge! the rate of increase of the sediments being probably less than one foot, and possibly not more than two or three inches in a million years. Now suppose that after a submergence of ten million years the floor of the deep ocean is slowly raised to form dry land. Is it surprising that a bed five or possibly ten feet thick of ferruginous clay, containing organic remains similar to those found in shore deposits, is not recognized as of abyssal origin, but is completely lost among the hundreds of feet of marginal sediments composing the new continent? In the ordinary sense, there are no abyssal sediments, but we find over these oceanic wastes merely the impalpable dust which slowly settles during the lapse of countless ages from the limpid water of the central sea. The land is the great theatre of erosion and the sea of deposition; but just as there are extensive rainless tracts on the continents where there is practically no erosion, so there exist still larger areas of ocean-floor over which the complementary process, or deposition, approaches the vanishing point. On both land and sea the main field of geological operations is marginal, following the shore-line; but nowhere does the earth's crust experience such perfect rest as under the deep sea.

The application of this principle to the explanation of the conformable contact of the Potsdam and Carboniferous over what must have been the central and abyssal areas of the Paleozoic sea is obvious. The first invasion of this sea spread over its floor a continuous sheet of Potsdam sandstone, which usually becomes calcareous upward. But, while the eastern and western marginal areas of the sea-floor continued to be the theatres of rapid deposition, the central areas soon became abyssal in depth and in the character of the deposits. That is, deposition was reduced to a minimum, or virtually suspended, over considerable tracts, during the Ordovician, Silurian and Devonian ages. When the movement of the crust was finally reversed, and the sea bottom was elevated during the close of Paleozoic time, the Carboniferous limestones were formed, passing up, usually, as in the Black Hills, into argillaceous and arenaceous strata which indicate a very marked shallowing of the sea. According to this interpretation, therefore, the stratigraphic record is continuous, but the middle chapters are so condensed as to be almost illegible, the history of Ordovician, Silurian and Devonian times in the Black Hills being, apparently, represented wholly by the few feet of ferruginous and highly argillaceous limestone separating the typical Potsdam sandstone below from the pure Carboniferous limestone above. Prof. Franklin R.

Carpenter, of the Dakota School of Mines, who kindly introduced me to some of the key sections in the geological structure of the Hills, arrived independently at the conclusion that the Paleozoic series here must be essentially unbroken.

Relations of the Paleozoic and Mesozoic Formations.

I had hoped, on entering the Hills, that my observations might contribute to the determination of the upper limit of the Carboniferous series. It is an unquestionable fact that nature has drawn the line between the Paleozoic and Mesozoic much less strongly in the west than in the east. As Newton has pointed out, the deposition was, apparently, nearly if not quite continuous in the Rocky Mountain region from the beginning of Paleozoic time to the end of Mesozoic time. Hence, in the almost complete absence of paleontological indications, it is not surprising that geologists have failed to agree upon a boundary line.

Above the variegated sandstone (the Minne Lusa sandstone of Winchell), which Newton places at the top of the Carboniferous, there follow the Red Beds, which include, in ascending order, 75 to 100 feet of red arenaceous clay, 15 to 30 feet of purplish, impure limestone and 200 to 250 feet of red clay with important deposits of gypsum. The upper or gypsiferous Red Beds, especially, form the floor of the great encircling Red Valley, which is walled on the side towards the hills by the purple and Carboniferous limestones, and on the outside, or toward the plains, by the hard Dakota sandstone at the base of the Cretaceous.

Although destitute of organic remains, the upper Red Beds are generally conceded to be Triassic, mainly because they are overlain conformably by beds containing characteristic Jurassic fossils. Winchell believed, however, that he detected an unconformity between the upper Red Beds and the purple limestone; and he consequently referred this limestone and the lower Red Beds to the Carboniferous. My attention was thus directed particularly to this supposed unconformity, the existence of which is denied by Newton. The exposures of this contact are, however, so unsatisfactory that I failed to find any decisive evidence; although in the vicinity of Spring Creek and of Whitewood Creek the appearances are certainly not unfavorable to the view that an unconformity exists.

Newton states that, although the close of the Jurassic age witnessed great continental and orographic changes in what is now the western part of the continent, the only effect in the vicinity of the Black Hills was a shallowing of the sea, none of the Jurassic sediments emerging sufficiently to suffer erosion. Prof. Carpenter, however, pointed out to me, on the south side of the gap of Rapid Creek, near Rapid City, distinct evidence that the Jurassic and Cretaceous beds of the Black Hills are not perfectly conformable. An artificial excavation at this point has exposed the contact of the two formations, and it is perfectly plain that the older beds were considerably eroded before the deposition of the newer.

AGE OF THE BLACK HILLS UPLIFT.

What is the age of the Black Hills uplift? and were all the formations now terminating in concentric lines of outcrop, often in encircling escarpments or ridges, from the Potsdam up to the Tertiary, once continuous across the central or Archæan area of the Hills? These are certainly among the most attractive problems presented by the geology of this region; but, although the student feels from the first that there is a fair prospect of reaching a satisfactory conclusion, a diversity of opinion has arisen.

That the Hills were in existence in Archæan time, and formed an island in the Potsdam sea, is certain. Newton says that "the inequalities of the Archæan shore became gradually filled up, and as the sea rose higher upon the land all that was not worn away at last became entirely covered by the Potsdam sea and its sediments. That the Potsdam stretched completely across the present area of the metamorphic rocks, we have undoubted evidence. There is nowhere observed any thinning out of the formation as we approach the centre of the Hills, but it everywhere maintains within narrow limits the same thickness."

This conclusion appears to me extremely improbable. (1) It cuts off, by covering up the Archæan ledges, the only known source of sand for the formation of the upper Potsdam beds. (2) Where the Potsdam now approaches nearest to the higher parts of the Archæan area, such as the Harney Range, its inclination or dip is manifestly insufficient to carry its base over their summits, especially if we consider that the Harney Range has probably been lowered several hundred feet by erosion, since the Paleozoic strata were removed from its flanks. My attention was first called to this point by Professor Carpenter. (3) Although Newton correctly gives the normal thickness of the Potsdam as from 200 to 300 feet, he is certainly in error in stating that this thickness is undiminished as we approach the Archæan heights. For his map shows that the Potsdam makes its nearest approach to the Harney Range on the east side, between Battle and Whiskey Creeks; and he explicitly states that its thickness at this point is only fifty feet. Fearing that this exposure might be simply an outlier from which the upper Potsdam beds had been removed by erosion, so as to make the determination of the true thickness at this point impossible, I visited the locality and was agreeably surprised to find a complete section. The Potsdam quartzite rests, with a gentle inclination away from the mountains, upon the highly inclined and eroded mica schists with veins of endogenous granite, and encloses fragments and grains of these rocks. After an almost unbroken exposure which would give a thickness not exceeding fifty feet (Newton's estimate), it is overlain conformably by the Carboniferous limestone. Here, then, where the Potsdam reaches farthest in toward the crest of the old Archæan island it is reduced to about one-fifth of its normal thickness. We must suppose, therefore, that the Potsdam period closed, at least so far as the deposition of arenaceous sediments is concerned, when the summit of the Archæan ridge sank beneath the Paleozoic sea; and that, while the Potsdam sandstone must have reached this crest, it could not have crossed it with any considerable thickness.

As already explained, the great apparent blank between the Potsdam and Carboniferous probably indicates a profound subsidence and the long-continued existence of abyssal conditions. At the dawn of Carboniferous time the deep sea, as indicated by the purity of the limestones, still covered, not only the Black Hills, but a very large part of the United States; and in the Black Hills, as elsewhere, the gradual shallowing of the sea during this age is proved by the fact that as we pass upward the Carboniferous strata become gradually more argillaceous and then arenaceous, the upper Carboniferous or coal measures consisting largely of sandstones.

The Appalachian revolution, which crumpled and elevated the Paleozoic sediments in the Alleghany region, the disturbance gradually dying out or changing to simple elevation farther west in the central part of the Mississippi valley, was repeated in the far west, in the Great Basin district, among the thick marginal sediments along the western shore of the Paleozoic sea, the disturbance gradually dying out or changing to simple elevation farther east, in the Rocky Mountain region and beyond. The Paleozoic ocean thus gradually became, during Carboniferous time, mainly a continental area, the elevation being, at the last, attended by plication, but only in the thick marginal zones of sediments.

The Black Hills uplift was essentially a restoration, so far as possible, of the conditions obtaining in this region in pre-Potsdam times; and, as thus defined, the beginning of the uplift certainly dates from the formation of the carboniferous limestone; and the uplift was, at first, not local but continental. Toward the close of Carboniferous time it had probably progressed sufficiently so that the summits of the main ranges of the Rocky Mountains were above water and afforded, by their degradation, the sands required to build the upper Carboniferous strata of the Black Hills.

The lower and upper Red Beds, with their impure limestone and beds of gypsum, seem to indicate a nearly stationary condition of the continent after the Appalachian revolution. During this period, the Black Hills were surrounded and probably covered by broad and shallow seas which were gradually silting up. We may well suppose that these Triassic seas exhibited, on a far larger scale, the conditions of the present playa lakes of the Great Basin.

The composition of the Red Bed series is, throughout, suggestive of shallow water. Even the purple limestone is so highly argillaceous as to be simply a consolidated calcareous mud; and, as I have elsewhere explained, the remarkably perfect shrinkage cracks which it exhibits at nearly all points and, apparently, through a considerable part of its thickness, oblige us to suppose that it was deposited in a shallow basin which was subject to periodic desiccation. These conditions would naturally depend largely upon an excessively hot and dry climate; and in the repeated exposure of the Red Bed sediments during their deposition to a hot and arid atmosphere, we have, perhaps, a satisfactory explanation of their prevailing red color, which is believed to be due to the partial dehydration, as well as the peroxidation, of the contained iron oxide.[1] Other important features of the Red Bed series, such as the beds of gypsum and the almost complete absence of organic remains, evidently demand similar physical conditions. The gray and ash-colored fossiliferous marls and limestones of the Jurassic series appear to indicate a subsidence at the beginning of this age, the lacustrine being, perhaps, largely replaced by oceanic conditions.

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[1] Proc. Boston Soc. Nat. Hist., XXIII, 219-222.

The uplifting of the Black Hills was not, of course, throughout simply a continental movement; for the marked tilting and plication of the strata on all sides, as we approach the Hills, prove a differential movement, the Hills rising with the continent, but more rapidly. That the Hills appeared as a distinct swell or local uplift, at least as early as Jurassic time, is probable, and if we conceive the deepening of the sea in the beginning of this age as taking place while the Hills were slowly rising, we may, perhaps, find in the quiet erosion of the rounded boss formed by the emergence of the Red Beds and the Carboniferous sandstones a suitable source of a portion of the Jurassic sediments, especially of the reddish and yellowish marls and sandstones, which occur chiefly in the upper Jura. A comparison of Newton's observations reveals the important fact that the thickness of the Jurassic series increases rapidly away from the Hills. It is about 200 feet immediately around the Hills, in the outer wall of the Red Valley, 400 feet in the Valley of Red Water Creek and 600 feet on the Belle Fourche, some forty miles from the main mass of the Hills. Although other explanations of this fact are perhaps admissible, it is certainly more consistent with the theory that during Jurassic time the Black Hills were slowly emerging and encroaching on the Jurassic sea, while the floor of adjacent portions of this sea remained stationary or actually subsided; than with Newton's view, that the sea covered the entire area of the Black Hills during the whole of Jurassic time. That the Jurassic sea in the vicinity of the Black Hills was shallow throughout is proved, as Newton has remarked, by the abundance of ripple-marks in the sandstones of this age.

Newton considered that the emergence of the Black Hills did not begin until the close of Mesozoic time. This view, however, not only appears inconsistent with the facts cited from the Jurassic formation; but it seems impossible to reconcile it with the oscillations of the crust and the erosion indicated by the unconformity between the Jurassic and Cretaceous at Rapid City, and with the conglomeratic character of much of the Dakota sandstone, the basal member of the Cretaceous. These grit and pebble layers of the Dakota group appear to have been derived from the Archæan rocks of the Hills.

At the close of the Cretaceous age the entire region of the Black

Hills became dry land and continued so during the older Tertiary or Eocene period. The advent of the broad shallow lake of the Miocene or White River Tertiary period is marked by a thin but very persistent bed of coarse loose conglomerate or gravel, which rests on the Cretaceous unconformably at some points. The pebbles and bowlders of this conglomerate have been derived chiefly from the Archæan quartzites and schists; and I also found in the Bad Lands of the White River, fully forty miles from the Hills, fragments of rose quartz and feldspar from the coarse granite of the Harney Range.

Although it is impossible, for the reasons indicated in the preceding paragraphs, to follow Newton in ascribing the uplift of the Hills wholly to the interval between the Cretaceous and Miocene, it seems highly probable that the main part of the differential movement, which is evidenced by the tilting and plication of the strata on the borders of the Hills, took place at this time. The cañon-like character of most of the drainage channels radiating from the central area of the hills also indicates that the present relative levels of the hills and the surrounding plains have not been maintained for any considerable period of geological time. The idea that the inception of the Black Hills uplift antedates the Cretaceous period was first suggested to me by Prof. Carpenter; and I am unable now clearly to distinguish my own observations and reflections on this subject from those for which I am indebted to him.

VOLCANIC PHENOMENA.

Intrusive Sheets and Laccolites.

The structural relations of the volcanic masses which dot the northern end of the Black Hills were as accurately determined by Newton as was, perhaps, possible under the circumstances of his survey and especially before the minds of geologists had grasped the idea of the laccolite. He saw that these masses are not volcanic in the ordinary sense of the word, that there are no surface flows, no scoriaceous, glassy or fragmental forms of lava, and that the cones are perfectly structureless masses, agreeing only in external form with the products of crater eruptions. He found the various stratified formations, from the Potsdam to the Cretaceous, dipping away from the eruptive masses in all directions, forming concentric circular outcrops about their bases and often exhibiting a high degree of alteration. He described the igneous cones in every case as pustular eruptions, conceiving that great volumes of lava had been forced up *en masse* in a viscid or semi-solid state; and not merely lifting the horizontal formations into arches or domes, but actually breaking through them. He evidently regarded the cones as essentially extrusive rather than intrusive, and their viscidity at the time of eruption thus became a necessary inference from the fact that the lava did not spread far from the vent or form flows. This view is, however, completely negatived by an important class of facts which Newton seems to have entirely overlooked.

The igneous rocks, which appear to be in the main of rather acidic types—rhyolite and trachyte—and approximately holocrystalline, being commonly called "porphyry" by the miners, occur in masses of three different forms: (1) The more or less distinct cones or mountain masses, already referred to. These properly embrace, besides such prominent topographic features as Bear Butte, Black Butte, Crow, Terry, Custer and Warren Peaks, the Sun Dance Hills and Inyan Kara, numerous broader, flatter and more obtuse masses or bosses, such as cover a large part of the surface between Black Butte and Terry Peak, and also southeast of Terry Peak, about the Deer Mountains. The broad and apparently thick masses of coarsely crystalline porphyry in the vicinity of Bear Butte Creek probably belong here. From these masses, which are undoubtedly, in some cases at least, thick intrusive beds from which the covering strata have been worn away, we pass naturally to (2) The more normal type of intrusive beds, which are exposed abundantly in cañon walls and by various mining operations, and usually range in thickness from five to perhaps fifty feet. They are found chiefly in the Potsdam sandstones and shales, with which they are usually perfectly conformable. It is not uncommon to find, as in the district on the east side of Terry Peak known as the Ruby Basin, from four to six intrusive sheets in one continuous vertical exposure; the thickness of the Potsdam partings, in some cases, scarcely exceeding that of the eruptive layers. (3) True dikes of porphyry, the feeders of all these intrusive sheets and cones, traverse both the horizontal sedimentary rocks and the underlying Archæan schists in every direction.

That these three structural types—cones, sheets and dikes—are parts of one connected system and merge into each other must be obvious to every geologist familiar with the facts as they are now exposed in the mining camps of the northern Hills. It is also plain that the thinness of many of the sheets and dikes implies a degree of fluidity in the porphyry which is entirely inconsistent with Newton's theory of viscid, pustular eruptions. On the other hand, all the facts, so far as I have observed, fully support the view that the great conical masses of Custer, Terry and other peaks and buttes are typical laccolites, of which the intrusive sheets so well exposed in the Ruby Basin and elsewhere are, in many cases at least, merely extensions and branches, as figured by Gilbert in his classic monograph on the laccolites of the Henry Mountains.

The laccolites seem to have accumulated in some cases between the Archæan surface and the Potsdam, more commonly, like most of the intrusive sheets, in the Potsdam itself, and sometimes, as in the case of Black Butte, mainly between the Potsdam and Carboniferous. Erosion has removed the covering strata in every case, exposing the crown of the laccolite, but they still reach high up on its slopes; and on Terry Peak I observed isolated patches of the Potsdam quartzite well up toward the summit. My attention was first directed to the intrusive sheets of the Ruby Basin by Professor Carpenter, and this district is certainly an admirable field for the study of the volcanic rocks. Ascending from the lower part of the Basin, we cross, first, the vertical Archæan slates and quartzites traversed by dikes of porphyry; and then the Potsdam beds with numerous intrusive sheets and dikes, sloping gently up toward the massif of Terry Peak, over which they undoubtedly once arched.

Contact Ore Deposits.

As in so many other districts in the Rocky Mountain region, the sedimentary rocks, and especially the Potsdam quartzites, are more or less highly metamorphosed and mineralized along the contacts with the porphyry sheets and dikes. These mineralized contact strata are the ore bodies of the gold and silver mines of the Ruby Basin and some other mining districts of the Black Hills. Being mainly horizontal, they are worked much after the manner of coal mines. So far as observed, the lower contacts are the most highly mineralized; that is, the richest mines are those in which the porphyry forms the roof rather than the floor. This fact is favorable to the view that the mineralizing process was mainly hydrothermal, since the heated mineral waters would naturally pass downward more freely than upward.

Concerning the source of the gold in the Ruby Basin ores, two opinions have arisen: (1) The gold was derived with the other constituents of the Potsdam quartzite from the auriferous quartz veins in the Archæan schists, the gold being sorted and concentrated by the waves of the Potsdam sea as by modern rivers. This view is supported by the fact that gold has been found in the basal conglomerate or cement beds of the Potsdam, even where it is not associated with the igneous masses. But gold worn from the Archæan veins by the Potsdam sea would naturally have been deposited mainly or wholly at the bottom of the nearest slope or hollow, and this would always insure its lodgment in the basal layer of the Potsdam gravel and sand. The occurrence of free or placer gold higher up in the Potsdam, say fifty feet above its base, would involve the very improbable conclusion that the gold, like the fine sand, had been carried by marine currents across several or many miles of the sea-bottom. Certainly, there would then be no tendency to concentrate the gold; but it would be diffused with inappreciable thinness through the whole body of the formation.

(2) The gold has been derived directly from the porphyry, and dates, in its present position, only from the metamorphism of the Potsdam beds. This view explains the occurrence of the gold in precisely the positions in which it is found; and is supported by the very important fact that numerous assays have proved that the porphyry is always auriferous, sometimes containing, as I have been informed by reliable assayers, over half an ounce of gold per ton. Although the exact condition or form of the gold in these ores remains to be determined, it is quite certain that it exists in almost infinitesimally small particles, precisely as if it had been deposited by chemical means. It seems fair to suppose that it was introduced by the same solutions which deposited the interstitial or secondary silica converting the sandstone to quartzite. This chemical explanation also accords with the occurrence of silver ores in these contact deposits in the eastern part of the Ruby Basin; for these could not possibly have been transferred by any mechanical means from the Archæan to the Potsdam.

Whether the gold of the Homestake and other mines situated in the ferruginous slates and schists of the newer Archæan series is derived from the associated porphyry dikes is an entirely independent question. Prof. Carpenter has answered it in the negative; and he is certainly justified, in the main, by the fact that similar ferruginous strata are distinctly auriferous outside the volcanic area. Still, after studying the Ruby Basin, it seems impossible to resist the conclusion that the porphyry is the actual source of some of the gold in the Homestake district; although its chief favorable influence has probably been to render the gold originally present more available.

Age of the Volcanic Rocks.

My observations sustain Newton's general conclusion that the volcanic rocks of the northern Hills are probably all of about the same age, and date from the period between the Middle Cretaceous and the Miocene Tertiary. They have upturned strata belonging to the Fort Benton Cretaceous group, and are enclosed as water-worn fragments in the Miocene conglomerate.

If the history of the Black Hills uplift is correctly outlined in the preceding pages, the summit of the uplift, which is plainly eccentric, being marked by the Harney Range in the southern Hills, must have been above the sea and exposed to erosion at least as early as the beginning of Jurassic time. It is even probable that erosion had cut entirely through the Paleozoic series, exposing the Archæan at some points, before the beginning of the volcanic activity; and it may be that we have here an explanation of the important fact that the igneous intrusions are limited to the northern Hills, which were probably an area of deposition till near the close of Mesozoic time.

ABSENCE OF GLACIAL PHENOMENA.

Geologists appear to be substantially agreed that the region of the Black Hills was not covered by the great ice sheet of the glacial epoch, and that they have not, in recent geological times, been the seat of any important local glaciers. These propositions are clearly established by the complete absence of true glacial drift, morainal deposits, large erratic bowlders and glacial striæ, and also by the wonderfully broken and jagged character of many of the topographic features of the Hills. The outcrops of the granite veins in the Harney Range, and of the vertical beds of Archæan quartzite, as well as the salient cliffs of the Carboniferous limestone afford particularly striking examples of the jutting crags, pinnacles, and knife-edges of rock formed, under favorable conditions, by the quiet and discriminating erosion of rain and frost. The narrow, craggy, vertical dikes or walls of quartzite and granite are from 50 to 500 feet high, and often transverse to the valleys or the necessary direction of glacial movement. It is simply impossible that they could have survived the glaciation of the hills, and highly improbable that erosion could have developed these features since the close of the glacial epoch.

The foot-hills, that is, the Cretaceous ridges or hog-backs outside the Red Valley, and the undulating or terraced surface of the plains for a distance of many miles from the Hills, are covered by a thin but very persistent layer of coarse gravel with numerous small bowlders from six to twelve inches in diameter, the largest observed being two feet. The pebbles and bowlders consist chiefly of the streaked Archæan quartzites of the Hills, but the coarse granite and diorite, the finer schists, and Potsdam and Carboniferous strata, as well as the volcanic masses are all represented.

This deposit, which rests alike upon the hardest and softest of the Cretaceous strata, and is found on the highest hills as well as in the valleys, could have been formed neither by an ice sheet nor by currents of water strong enough to transport such coarse material. Newton conceives that during or at the close of the glacial epoch the region about the Black Hills was submerged; and the detritus in question was carried outward from the Hills in all directions by icebergs. This explanation is, however, seriously weakened by the complete absence of all other evidences of lacustrine conditions at this time.

My own observations have satisfied me that the gravel and bowlders are a residual deposit; and attention is invited to the following general considerations which tend to establish this view: (1) The Miocene beds must once have covered all the area where the gravel and bowlders are now found. (2) The base of the Miocene is, as already noted, a bed of very coarse and loose conglomerate or gravel, which is essentially identical with the surface gravel and bowlders, if we make a reasonable allowance for the Miocene gravel having been coarser near the Hills than where it is now exposed *in situ* in the Bad Lands, forty miles from the Hills. (3) It is highly probable that the erosion of the Tertiary strata has been throughout, as now, a very quiet and gentle process. (4) The hard pebbles and bowlders of quartzite, etc., now covering the whole face of the country, are, except in the actual beds of the streams, virtually proof against removal or disintegration under existing conditions. In short, the quiet erosion of the soft clays, muds and sands forming the Miocene and Upper Cretaceous beds has left these indestructible pebbles and bowlders essentially intact; and as they are now, we may expect they will remain until some future submergence hands them down to a later sedimentary formation. The sufficiency of this explanation is further attested by the fact that in the Bad Lands many of the hills and slopes are thickly strewn, often to the depth of several inches, with angular fragments of the chalcedony which forms thin veins traversing the soft Tertiary beds. Even in the stream beds, these fragments of chalcedony are usually but little rounded; and we may fairly suppose that the fragments which now encumber the surface represent a considerable thickness of clay and marl which has been washed away, the chalcedony, like the rolled pebbles from the Miocene beach, remaining behind as an inert residuum.

Professor Hyatt spoke of some features in the geology of Lake Huron, confirming views expressed by Professor Crosby.

The Curator showed a male and female Kiwi, wingless birds from New Zealand, presented by Messrs. W. C. Pope & Co. of Boston, to whom the thanks of the Society were unanimously voted for this gift.

GENERAL MEETING, MARCH 21, 1888.

The President, Prof. F. W. PUTNAM, in the chair.

The following vote of the Council was read:—

Voted: That the Council, having duly considered the correspondence which has passed between a Committee of our own number and the Park Commissioners just published, asks the Society to authorize the Council to take such steps as shall be necessary to secure to the City of Boston a Natural History Garden and Aquaria, which shall then be under the direction of the Society.

The President spoke briefly in regard to this vote and stated that a special meeting of the Society would be called to consider the action of the Council.

The President then read a very interesting paper on the "Serpent Mound" in Adams County, Ohio, which has recently, through the aid of friends in Boston and vicinity, become the property of the Peabody Museum.

In the introduction he stated that the paper was complimentary to the ladies and gentlemen who subscribed for the purchase of the mound and the grounds about it. He then gave an account illustrated by stereopticon views of different portions of the Mound and its neighborhood.

Some excavations have been made but rather to restore the mound to its original normal form which is at present preserved. A skeleton of huge size found in a smaller mound near by was spoken of. Views of this and other skeletons found near by were shown on the screen.

The following paper, also illustrated by the stereopticon, was read:

ON THE ORIGIN OF THE PRESENT FORM OF THE BERMUDAS.

BY J. WALTER FEWKES.

The contours of the several islands which form the isolated group of coral formation called the Bermudas, are curved, crescentic or ring-shaped. The whole archipelago rests on an oval foundation or platform, and a marked feature of its outlines is the existence of lagoons, enclosed or partially open circular basins of water called sounds. The whole group is geologically formed of a soft æolian limestone made up of calcareous fragments of the skeletons of corals, and many other animals.[1]

The contour of the islands strongly reminds one of the compound atolls or ring-shaped coral reefs so abundant in the Pacific and Indian oceans, and they have been described as atolls by several writers, among whom may be mentioned Dana, Thomson and Rice.

Professors Dana and Rice have ascribed the present form of the

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[1] This paper is preliminary to one in which the general and special facts, touching on the theory that the present contour of these islands is due to erosion rather than to subsidence, will be considered. The literature is considered in my final paper.

Bermudas to subsidence of the foundations upon which they rest, showing in the Atlantic one of the few verifications in that ocean of Darwin's beautiful theory of the formation of ring-shaped atolls by submergence of the sea-floor.

It is believed, however, that the present general contour of the Bermudas, the crescentic islands and the partially or wholly enclosed sounds,[1] are due to erosion of the rock by the sea rather than by subsidence of their foundation. It is also held that the present Bermudas are but small parts, veritable fragments of a much larger island, which once covered a greater area of the oval foundation. The present islands lie on the southern rim of this platform. It is not necessary to suppose that the present Bermuda is a compound atoll due to subsidence of the sea-floor, but the well-marked sounds and lagoons can best be explained as inroads made by the erosion of the sea on the soft rock of which the islands are composed. Analogous forces are now at work on the islands, completing the work which was begun long ago. These forces show here and there over the islands on a smaller scale the same results and the same circular lagoons which on the map give to the islands such a close resemblance to the Pacific ocean atolls.

Coral islands are divided into two great groups: 1. Those in the process of formation. 2. Those in the process of decay.

The best illustration of the former group in the Atlantic is the well-known Florida Reefs. Here we have a series of low islands in places much eroded, but nowhere rising very high above the level of the sea. The forces of formation are active. The islands lie in the zone of a profuse coral life and in the neighborhood of an oceanic current well stocked with smaller marine life, which serves for the food of the corals.

The Bermudas are good illustrations of the second kind of coral islands, or those in process of erosion. They lie distant from the equator where coral life has been evidently more luxuriant formerly than at present. They are riddled with caves, grottoes and submarine chambers due to erosion. Their surface is covered with a red soil of characteristic composition. Here the forces of decay, or of destruction of the land by erosion, are active. The building of the coral island is here finished, and the sea and air now conspire to level it below the surface of the ocean.

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[1] Castle Harbor, Great Sound and Harrington Sound.

With the problem of why the foundation of the Bermudas is oval in form, and whether elevation or depression of the sea-floor upon which they rest has ever taken place, we are to deal only so far as they are supposed to effect the present form of the islands. That local subsidence has occurred there is little doubt, from the finding of cedar trunks, red soil and land Helices in submarine caverns.

These facts, however, by no means prove a general subsidence of the whole platform of the islands. In the same category may be placed the observations of stalactites in grottoes under the sea-level. It is not strange that such local submergences should occur, but I cannot accept the theory that they indicate a subsidence as widespread as the platform upon which the present islands rest.

There are many ways in which the Bermudas differ from true atolls formed by subsidence, some if not all of which were pointed out by Darwin. Although nowhere very lofty, still the highest elevation of the Bermudas is far above that of any of the Pacific atolls. The fact that the water shoals somewhat near the islands is also not characteristic of true atolls of subsidence, which generally rise abruptly from the abysses of the ocean. While there is nothing to show that subsidence has not taken place, there is reason to believe that the present Sounds of the Bermudas, which on a map so closely resemble the atolls of the Pacific, are formed by very different processes from the atolls of the South Seas. An explanation of the present form of the Bermudas must give an important place to the agency of erosion. We find at present the destructive powers of water and air present everywhere on the island. Sea and rain combine to level the islands and to wash them into the sea. The amount of this erosion is something perfectly enormous, and no one who has always lived over hard New England rocks can justly estimate the amount of wearing away year by year by the sea of the soft cliff of coral rock.

Everywhere in Bermuda there is evidence of this erosion, and grottoes, caves and caverns, water courses under the land, sink-holes caused by the settling of the roofs of caverns, occur everywhere. The cliffs of the shore are worn into pinnacles, columns and natural archways. The land in some places sounds hollow to the tread. The basin called Harrington's Sound, with the exception of a small entrance at the Flats is completely surrounded by land, yet at every flood of tide the water pours into it by subterranean channels. Along the south shore the cliffs are worn into fantastic shapes showing everywhere the inroads which the sea is making on the soft æolian limestones of the islands.

It seems to me not a great mistake to compare the large lagoons or sounds with similar, though small productions of this erosive power of the water everywhere visible throughout these islands. There is no reason known to me why we should limit the power of erosion to caverns of a few hundred feet in size, and not accept the undoubted truth that these smaller basins are due to this force while the larger sounds arose by subsidence. There is nothing but size which distinguishes Castle Harbor from a cavern, the roof of which has fallen and been washed away ; both are thought to belong in the same category and were probably formed in the same way.

The lofty cliffs bordering a part of Harrington's Sound show that its wall has suffered great erosion. If the cliff is extended to its original size before this erosion, it would very much reduce the size of the sound itself. The presence of islands in Harrington's Sound with cliffs of some altitude also indicates extensive erosion. If these were restored to their original extent, the size of the sound would be very greatly limited.

One great objection which might be urged against regarding the sounds of the Bermudas as due to the falling in of caves, due to erosion of the sea, is the fact that there are so few islands in them, or such small remnants of their former supports. When we reflect, however, that the erosion of the water possibly went deep into the submarine rocks, the depth of the eroded portion might be great enough to submerge a large part of the roof after it had fallen.

Why, it may be asked, are some of these sounds, as for instance, Castle Harbor and Harrington's Sound, separated by a narrow stretch of land, and why is Hamilton's Sound shut off from the sea by such a narrow strip of soft limestone? It would seem as if both these barriers would have long ago disappeared under the same forces which formed the sounds, and as if instead of a basin, partially enclosed, we ought to find a simple wearing away of the coast lines into deep bays and gulfs. While the contiguity of two sounds as Harrington's Sound and Castle Harbor, and the separation of either from the ocean by the narrow strips of land, would seem effectually to discredit a belief that they were formed by erosion, it is possible to ascribe the arrangement to a secondary condition.

While many might accept the theory that the sounds of Bermuda are due in part to erosion rather than to submergence, others would find difficulty in the acceptation of the theory as far as the whole reef of the Bermudas is concerned. The oval and circular form of the platform on which the Bermudas rest, and the ring-shaped reef, are often adduced as evidences of the atoll character of the islands. It can, on the other hand, hardly be urged, however, that they prove any submergence, even if it can be shown that the Bermudas were formerly much larger than they are at present.

The isolated remnants of what may be known as the old Bermudas, now called the North Rocks, show how much erosion has taken place, and indicate how much larger the islands formerly were. They do not prove submergence, but only the great erosion of the rock by the sea.

Is it possible that in former times the Bermuda was a compact island, reaching from the North Rocks and the line of the North Reef to the present land of Bermuda? Was the oval platform of the islands formerly covered by land of the same shape as the submarine platform? It seems to me necessary to suppose, at least, that the platform was fringed by high lands possibly much higher than the highest point of the present islands. On the southern border of the platform this land remains almost continuous from St. Georges to Ireland island. The North Rocks are remnants of the same on the northern side. Historically, as well as geologically, the evidence is that the reduction in size of the last mentioned has been great in late times.

It is of course not necessary, even if we have accepted the theory that there was a ring-shaped island or series of islands skirting the present platform, to ascribe this form to submergence. Its contour in old times may or may not have been ring-shaped. My desire this evening is simply to show that the present form is mainly due to erosion.

The Bermudas are regarded as islands carved out into circular reefs by the inroads of the sea. These inroads have taken place in comparatively recent times. While it is not denied that subsidence may have taken place in the floor of the ocean upon which the Bermudas rest, that subsidence has not led to the peculiar ring-shaped sounds and reefs which characterize the Bermuda islands as a whole.

Mr. Alexander Agassiz made a few remarks on the last paper, suggesting difficulties to an acceptance of certain of the views advanced. He spoke of the existence of living coral in lagoons on the Bermuda reef ascribed to erosion, and of the high cliffs of æolian limestone in the Sandwich islands.

SPECIAL MEETING, MARCH 28, 1888.

The President, F. W. PUTNAM, in the chair.

THE President stated that the meeting had been called to consider the following vote of the Council.

Voted, That the Council, having duly considered the correspondence which has passed between a committee of our own number and the Park Commissioners of the City of Boston, as set forth in the Report of the said Commissioners just published, asks the Society to authorize the Council to take such steps as shall be necessary to secure to the City of Boston a Natural History Garden and Aquaria which shall then be under the direction of the Society.

After a short address the President invited the Society to listen to a report on the proposed garden by Mr. Samuel H. Scudder of the committee of the Council.

Mr. Scudder said:

The idea of a zoological garden in Boston is by no means a new one, and, as I chance to have been connected, from the beginning, with the movement to establish one, it falls to my lot to give a slight historical sketch of what has been done. Much impressed with the interest attaching to the gardens in Europe during a visit to some of the principal cities, I brought the matter to the attention of the Council twenty odd years ago, and a committee was at that time appointed to consider the subject and to report at a suitable time. That committee has been in existence, though a portion of the time in a moribund condition, ever since. No entry appears to have been made on the records at that time, but some of the subsequent revivals of the same do appear. One occasion for renewing the subject came at the time when our Boston public park system was first broached, and at a meeting of the Society June 3, 1874, the Council was asked to appoint a new committee to "urge before the Park Commissioners and the City Council the importance of establishing a zoological garden and aquarium in connection with one of the proposed public parks." The committee was again revived about two years ago with some alteration of its members (which have remained practically the same since the initiation of the project) and latterly has held several conferences with the Park Commissioners, the result of which appears in the correspondence which has been printed in the recent report of the latter body.

It was at one time hoped that a piece of ground at no great distance from the thickly settled part of the city might be obtained, and there was much discussion of the possibility of securing a foothold on the Francis estate. But as time passed on and one piece of ground after another was brought into the market and occupied, it became only too evident that our sole resource was in the willingness of the Park Commissioners to coöperate with us in our undertaking. Even with their aid it seemed hopeless to try to procure sufficient ground in any one place to establish a garden on any plan sufficiently extended to merit the approbation of the citizens of Boston. Indeed the character of the country about Boston, where it is difficult to find any diversified ground with a considerable amount of flowing water in its near vicinity which could be utilized for the needs of an aquarium and aquatic animals, would render the selection of a suitable place, even were every district at our disposal, a difficult task ; and inasmuch as in such gardens as were proposed it was only necessary for certain animals that they should enjoy an abundant water supply, the solution of the difficulty seemed to lie in arranging for several pieces of ground, some of which would answer for one purpose and some for another. This solution has met its best response in the action of the Park Commissioners in conference with our committee. They have, as you know, now reserved for our use certain areas of land under their control, one of which, that part of Franklin Park lying on the city side of the Playstead and the Greeting, consisting of about forty acres and containing diversified rocky ground in part abundantly wooded, would answer excellently for the natural history park proper, to contain the ordinary animals which do not require an extensive water supply ; a second piece consists of well-watered ground in the vicinity of Jamaica Pond suitable for aquatic animals ; and there are besides two points in East and South Boston, situated at the seashore, which would answer admirably for aquaria. At first sight such a distribution of the proposed natural history park into several separate establishments may seem highly disadvantageous, and it is a division such as has never before been attempted in a zoological garden. It would obviously require a larger staff to operate it, but it may be claimed that there are certain advantages which here at least would quite offset these objections. It is thus possible to obtain for aquatic animals places especially suited for them, and to select ground of a very varied character without feeling dependent upon a great water supply; while, by establishing the aquaria at the very edge of the harbor, there are very obvious advantages, especially when it is pointed out that it is proposed to utilize an artificial arm of the sea under construction, inclosing a huge basin in which it would be possible (what has never before been attempted) to see some of the larger marine animals sporting at pleasure. But the prime advantage of this distribution is in the fact that all our citizens are brought into near proximity to some part of the ground occupied.

Probably no large gardens have ever been successfully carried on in any city which is practically so far north as Boston, that is, one in which the winters are so rigorous. It became, therefore, a question of importance for the committee to decide as to the precise nature of the proposed garden. It was pretty evident that the attempt to display such a collection of animals as may be seen, for instance, in the largest cities of the Old World, and especially in London, would here be attended with a far greater expense than there; inasmuch as the artificial requirements of heat would not only be greater but more prolonged than in a more temperate climate. It was deemed also essential to the value of any such scheme, especially if carried on under our own organization, which is founded for the advancement of science and has the education of the people at heart, that the garden should be established upon such a basis as would enable it to become an important educational factor, and prove its own right to exist by its value to our children. How many of our citizens,—rather I may ask, how many even of those present here at this Natural History Society this evening are acquainted with all the native quadrupeds of New England? To become familiarized with the animals of our own land, of our own home, is the one point which should be emphasized in the attempt to organize any garden in our own immediate vicinity. It is this side of the question which the committee has emphasized in its letters to the Park Commissioners; and to carry out this plan it would be essential above all other things that the collection should be eminently an American one, and preëminently one in which the fauna of New England should find a place. The support of such an establishment, carrying through the year such animals as are accustomed to endure the rigors of our native climate, would prove a vastly different undertaking from any attempt to introduce a collection of purely tropical animals and carry them successfully through our severe winters. This would familiarize the city boy with the appearance, habits and life of animals which surround him, but which by his circumstances he rarely even sees. But of this educational side of the question others can speak much better than I.

This, then, in general, is the scheme which has been devised, to which we invite your attention, and for which we ask your suffrages if so inclined. As to the method of carrying this out, it is plain at the very outset that no such scheme can be carried on without a very considerable fund behind it. The Society itself has no means it can divert to such a purpose, and it can only afford to support and administer such a new undertaking on the basis of a special fund for that purpose. It has seemed, therefore, to the committee necessary that two things should be undertaken to enable the Society to carry on this laudable enterprise. First, the friends of the Society should raise a fund of $200,000, a permanent fund as a basis for the undertaking; a guarantee fund, of which the principal, or at the very least one-half of it, should on no account be infringed upon; the source of a revenue, which should make it forever certain that no temporary misfortune to the garden should cripple the legitimate work of the Society in the sphere with which it has hitherto contented itself, but that the funds heretofore given to the Society, whether encumbered or not with special conditions, should be regarded as forever sacred to the uses to which they have hitherto been put. The second condition which the committee has thought necessary to the financial success of the scheme is that a body of members should be brought into the Society through the attraction which the garden would offer, paying an annual fee as their contribution towards its support, and receiving in return the privileges which membership would give. On this basis, the regular sources of income would be the annual interest of the permanent fund, or as much of it as might be needed, the park membership fee and the receipts at the gate. From these and from other incidental sources it has been roughly estimated that perhaps $30,000 might be annually raised, and this was considered ample for the present maintenance of the garden; for it was not intended to push the scheme to its full proportions at once, but rather to move forward with prudence and without too great ambition. The plan, in fact, is to have an establishment which should be complete in itself at the start, good as far as it went, but not at the first grand.

The President invited several members to state the reasons which had led them to approve the project.

Professor W. T. Sedgwick spoke of the educational value of a Natural History Garden in Boston. The theory of the evolution of animals the speaker thought could be illustrated in the proposed garden and aquaria by gradations of animals. He lamented that a child formed an erroneous conception of animals from books and thought the specimens in the proposed garden and aquaria would offer needed corrections.

Professor Hyatt also emphasized the importance of the proposed garden as a means of popular instruction.

Mr. T. T. Bouvé spoke briefly in favor of the proposed garden.

Mr. M. D. Ross, chairman of the committee on the proposed garden, warmly supported the plan of a Natural History Garden and was glad the work of the committee was drawing to such a propitious close, to which Professor Hyatt replied that with the large sum of money to raise the work had just begun.

Mrs. Hopkins spoke of the difficulty in teaching natural history in the public schools from want of just what a natural history garden and aquaria would give, viz., living specimens for object teaching.

Mr. C. L. Flint was in favor of the garden and aquaria. He thought there would be no serious difficulty and that the plan would be a success.

Dr. E. G. Gardiner spoke of the Philadelphia Natural History Garden and showed by tables the expenses, gate receipts and average attendance.

Miss Isabel F. Johnson believed that a part of the required fund might be raised by penny or small subscriptions from school children.

The President spoke of the interesting exhibits of pisciculture which might be made in the proposed aquaria. He said he could not call upon any one in particular in opposition to the plan because he had heard of no one who was opposed. He invited any one to speak who had anything to say in opposition. No one responded directly to the invitation.

Dr. B. Joy Jeffries confessed that when it was proposed to raise $200,000 by subscription, it almost took his breath away. He approved the enterprise and was sustained in favoring the practical step proposed in view of what, on former occasions when great enterprises were pending, the citizens of Boston have done in the way of generous contributions. He felt also that the city of Boston would be laggard if it much longer postponed such an undertaking and named several cities where zoological gardens have been prosperously carried on. Moreover, he had the utmost confidence in the caution and good management of the committees of the Society or Council which will have charge. The committees have always been noted for economy, and he never knew them to spend money for luncheons, but recognized a departure on the present occasion in seeing that a lunch had been spread in the library hall.

The President said that the lunch did not affect the reputation of the committees as it had been provided at the expense of the ladies of the Society, and he improved the opportunity to invite all to partake of it at the close of the meeting.

Dr. George Waters said he should vote for the plan if it was pressed, but counselled the members to take more time for consideration and have the matter voted upon at an adjourned meeting.

Mr. S. H. Scudder responded that the plan of a Natural History Garden had already been considered for twenty-one years.

Dr. Bowditch offered the following resolution and vote:

Resolved, That this Society cordially and fully approves the steps taken by its Council in the matter of Natural History Gardens and Aquaria.

Voted, That the Boston Society of Natural History authorizes the Council of the Society on its behalf to proceed with the establishment of such gardens and aquaria, whenever the sum of $200,000 shall have been raised for that express purpose, provided that of that sum $100,000 be forever set apart as a guarantee fund of which the income only shall be available for current expenses, building and other items of maintenance or construction, and that after the fund of $200,000 has been raised and the reserved fund has been invested, the Council shall not incur an indebtedness beyond the sum of eight-tenths of the actual value of the investments of the reserved fund.

Mr. Samuel Wells seconded the resolutions and motion which were then unanimously adopted.

GENERAL MEETING, APRIL 4, 1888.

The Vice President, Prof. G. L. GOODALE, in the chair.

The following obituary was read:

A NOTICE OF THE LIFE OF THE LATE RICHARD C. GREENLEAF.

BY SAMUEL WELLS.

RICHARD CRANCH GREENLEAF was born in Cambridge, Mass., in 1809 and died in Boston on August 3, 1887. At the early age of thirteen he entered the dry goods business in Boston and continued with great industry and activity to devote himself to work until his death. As the senior member of the house of C. F. Hovey & Co., he was the oldest merchant in that department of business in the city. In his business relations he was esteemed and respected for his strict integrity and freedom from all guile. He was a leader among those Boston merchants who have proved by their lives that it is possible to be always honest, true and pure and yet be successful.

With all his devotion to business he was interested in works of philanthropy and the pursuit of science. He was at all times generous to others not only with his money, but with his time, and no one ever called upon him, even in his busiest hours, without receiving a kindly reception and an attentive hearing.

He was interested in the Home for Aged Men and succeeded the Hon. Otis Norcross as its President. He was in the government of the Institute of Technology for several years and was for some time Vice President of the Franklin Savings Bank.

Mr. Greenleaf was married early in life to Miss Mary P. Whitney, daughter of Rev. Peter Whitney of Quincy. Mrs. Greenleaf is still living and their only child, Dr. Richard C. Greenleaf, now resides at Lenox in this state.

It is, however, with his interest in natural history that this Society is especially concerned. His general knowledge of organic life was extensive, but his particular study was the use of the microscope. The facility with which this instrument can be used in the evening was evidently one of the reasons that attracted him to it, as he was seldom away from his place of business during the daytime. He acquired a large and valuable collection of microscopical apparatus and paid much attention to the construction and use of high power objectives. It was largely due to his liberality and encouragement that the late Robert B. Tolles was enabled to take up his residence in Boston and progressively improve the construction of his objectives until his reputation as a skilful optician became world-wide.

Mr. Greenleaf understood thoroughly the theory and construction of the microscope and his skill in its manipulation was excellent. For his particular study he selected a group of algæ known as the Diatomaceæ, and was one of the earliest students of this family in the country. He made a large collection of them and of the literature descriptive of their varied and beautiful forms. About 1860 or 1861 he found a new and finely ornamented species which he named *Stauroneis Stodderii* in honor of his friend the late Mr. Charles Stodder, a member of this Society for many years, and an authority on the Diatomaceæ. This species is described in a paper "On Extreme and Exceptional Varieties of Diatoms, etc.," by F. W. Lewis, M.D., published in the Proceedings of the Academy of Natural Sciences of Philadelphia, January, 1865.

In 1869, Mr. Greenleaf made a communication to this Society on the subject of "The Double Plate of Aulacodiscus Oregonus." It is unfortunate that so careful an observer did not favor us with more of the results of his work.

Mr. Greenleaf became a member of this Society on December 5, 1860, and gave freely of his time and money to its purposes, especially in the department of microscopy, during the rest of his life. In 1870 he was chosen a member of the committee on microscopy, which made him a member of the Council. In 1871 he was elected second Vice President and continued to hold that office until 1874.

In 1877 Mr. Greenleaf with Dr. A. D. Sinclair presented to the Society 477 slides of microscopical objects prepared by Mr. William Glen, a valuable and interesting addition to the collection of slides. Mr. Greenleaf further manifested his interest in this Society by bequeathing to it his microscopical library containing several rare and valuable works, his apparatus and collection of slides, consisting of two Tolles' stands, one large and one small, nine objectives, and a variety of accessory apparatus, also about 2150 slides of which about one-half are diatoms and the rest anatomical, botanical, entomological and miscellaneous.

In the death of Mr. Greenleaf, the Boston Society of Natural History has sustained a great loss; those who were associated with him as officers and members feel it as such a personal grief that they will not soon forget his kindly advice and generous aid.

The following paper was then presented:

THE DEVELOPMENT OF THE OYSTER WITH REMARKS ON ALLIED GENERA.

BY ROBERT T. JACKSON.

The paper here presented is a preliminary paper on the later development of the oyster, with studies of allied genera. In the portion treating upon oysters, I have entered more into detail than was my first intention, but this seemed necessary in order to make a reasonably clear presentation of the facts.

Bibliographies of the development, life-history and culture of the oyster, are to be found in the works of Professors Brooks (4)[1] and Ryder (21), and Dr. R. Horst (7). A comprehensive essay on the life-history of the oyster has been published by Prof. John A. Ryder (25), and many papers exist in the Reports and Bulletins of the United States Fish Commission, from 1880–86 inclusive.

The investigations were carried on by me as a pupil of Prof. Alpheus Hyatt, and the main lines of research are similar to those followed by that author in his studies of the development of fossil Cephalopods. An attempt has been made to apply his classification to the later development of the oyster, and the stages of growth have been named[2] in accordance with his system (13), which was presented before the Society November 16, 1887.

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[1] References to papers quoted are referred to in the text by numbers in parentheses, of which a list will be found on p. 548.

[2] It is necessary to anticipate by means of a note a brief description of two names used in the text, in order to make clear their meaning in the first part of the paper. The adult shell of cephalous molluscs has been called the conch or true shell, and the young first formed shell on account of its differences, the protoconch. Similarly the young shell of Dentalium has been named the periconch. The adult double shell of an oyster is believed to be the homologue of the adult single shell of cephalous molluscs, and in view of its double character I suggest for it the name *dissoconch* (double shell). The first formed shell of an oyster is strikingly different from that which immediately succeeds it, and which is retained throughout the rest of life. It is different in form, histological structure, and covers very different organic soft parts. It is thought to be the homologue of the protoconch of cephalous molluscs and the periconch of Dentalium, and is, therefore, named the *prodissoconch* (early double shell). The detailed consideration of the reasons for this nomenclature is given on pp. 540, 542–543.

The stages described and named in that essay, as the protembryo, mesembryo, metembryo, neoembryo and typembryo, are to be found in following the early development of the oyster, though the concentration of development[1] is so great that they overlap one another. In the present paper the first application of the theory will be to the early single-muscled stage.

The first oyster material which I had for study was some very young spat sent to Professor Hyatt, by Prof. J. A. Ryder. During the summer of 1887, a large amount of material was collected at Buzzards Bay, Massachusetts, where oysters were secured on artificial cultch of pottery, wood and glass,[2] as well as on natural cultches of shells and stones. The studies of fossils were made while arranging collections as Professor Hyatt's assistant in the palæontological department of the Museum of Comparative Zoölogy. I also had free access to the collections of the Boston Society of Natural History.

Before turning to scientific considerations, a point in the life-history of the oyster is worth noting. One of the most successful spatting grounds at Buzzards Bay, is a sand spit in South Wareham, formed by the dividing waters of the tide, as it rises and flows on the one side to Buttermilk Bay, and on the other to Onset. The strength of the tide is very great at this point. The bar at low tide was bare for about four hours during the time when oysters were setting most abundantly late in July and early August. Here, then, the young oysters, which are exceedingly small when first attached, bear exposure for several hours daily to the air and sun, which dries up all appearance of moisture on the rocks and shells to which they are attached. Further, the spat not only sets and grows but develops quite as rapidly during summer as in localities covered by water all the time. They are removed in late autumn by the oystermen to deeper water, and no oysters reach maturity on the bar.

Lamellibranchs are divided into three groups, according as the adults have a single adductor muscle, monomyarians; two equally developed muscles, dimyarians; or again, two muscles, one large and functionally the most active, the other smaller, heteromyarians.[3] It is of great interest to know what are the relations between these groups, and it is believed that the later development of the oyster throws light on the problem.

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[1] For Professor Hyatt's theory of the concentration and acceleration of development, see reference No. 12.

[2] The details of the methods of procedure have been briefly described in "Science" since this paper was read. See reference No. 14.

[3] Those grouped as heteromyarians do not always have two muscles.

DEVELOPMENT OF THE SOFT PARTS.

The early embryological development of the oyster may be followed in the writings of Dr. R. Horst (6, 7), on the European oyster, *O. edulis* L. and Professor W. K. Brooks (4) on the development of our oyster, *O. virginiana* Lister. The later stages of development have been studied by Professor Huxley (8), and Dr. R. Horst (7), in the European oyster, and Professor J. A. Ryder, in our species.

The lamellibranchiate identity of the embryo is first emphatically marked when two valves are seen to have resulted from developing growth of the preconchylian gland (Horst's (7) fig. 14). The mouth and anus, when developed, arise in close proximity on the ventral aspect of the embryo (Brooks' (4) fig. 38), a generalized molluscan embryo characteristic. The velum which existed before this stage is clearly marked off, lying directly above the mouth.

A little later (Horst's (7) fig. 15), the development of the first adductor muscle begins in the middle anterior part of the body, and close to the dorsal margin of the velum. The retractor muscles of the velum and liver develop. The anus revolves in the plane of the valves through a considerable angle toward the dorsal aspect of body (see Brooks' (4), figs. 38–44). The intestine by interstitial growth makes a single loop-like curve on the left side; this with some other slight changes brings us to the stage figured by Professor Huxley (8) (see this paper fig. 1, pl. IV). Ryder (23), in remarking on this stage, notes that the intestine is already flexed on itself, in much the same manner as in the adult, though it does not extend as far anteriorly, and its position is modified later by flexions of the stomach.

Professor Huxley (8), in speaking of the single adductor, says: "It is a very curious circumstance that this adductor muscle is not the same as that which exists in the adult. It lies in fact in the fore part of the body, and on the dorsal side of the alimentary canal. The great muscle of the adult, on the other hand, lies on the ventral side of the alimentary canal and in the hinder part of the body, and as the muscles, respectively, lie on opposite sides of the alimentary canal, that of the adult cannot be that of the larva which has merely shifted its position; for in order to get from one side of the alimentary canal to the other, it must needs cut through that organ. But, as in the adult, no adductor muscle is discoverable in the position occupied by that of the larva, or anywhere on the dorsal side of the alimentary canal, while on the other hand there is no trace of any adductor on the ventral side, in the larva, — it follows that the dorsal or anterior adductor of the larva must vanish in the course of development, and that a new ventral or posterior adductor must be developed to play the same part and replace the original muscle functionally, though not morphologically." He also notes that the cockle has at first, like the young oyster, only one adductor, which answers to the anterior of the two adductors which the cockle possesses in the adult. This is up to the present time all that has been known concerning the adductor muscles of the young oyster.

The next stage, fig. 2, pl. IV, in the development which I have to consider, is that of an oyster which had completed its prodissoconch and a very slight spat growth had taken place on the ventral margin. The specimen, preserved in weak alcohol, was removed lately from cultch on which it had grown in Buzzards Bay during last summer. The calcareous portion of the shell was dissolved with dilute acetic acid, and the main features of the anatomy could then be seen. The velum had disappeared. The mouth from its previous ventral position (shown in fig. 1, pl. IV), had revolved dorsally, in the plane of the edges of the valves, similarly to the anus, but in the opposite direction, and had stopped beneath the still existent first-formed adductor muscle, fig. 2, pl. IV. This muscle apparently checked its farther revolution dorsally. Continuous with the mouth is the œsophagus which is directed dorsally. Immediately below the mouth is a large organ, which is probably the developing palps. The gills are developed considerably on the ventral aspect. The chief and most interesting feature of this stage, fig. 2, pl. IV, is the existence of a second adductor muscle, in the posterior portion of the body, of about the same size as the anterior adductor. This muscle occupies a position below the terminus of the intestine, which organ wraps around the posterior aspect of the muscle, as it does in later stages, and in all adult Lamellibranchs.

We have then the interesting feature of a monomyarian Lamellibranch, in its young stages possessing two muscles, situated relatively to the alimentary canal as they are in typical adult dimyarians. As noted above, the anal part of the intestine revolved dorsally during the early development of the oyster, and it is evident that the posterior muscle when formed must have originated on the ventral aspect of that organ. If the posterior muscle were developed on the dorsal side of the intestine it would always have retained that relative position, as the permanent anterior adductor of dimyarians does in relation to the mouth and œsophagus. It does not seem likely that the intestine would first force itself past an existing muscle, and then, when it got on the dorsal side, wrap its terminal part around the dorsal aspect of that muscle, as it does in all adult Lamellibranchs. One of the striking characteristics of the ostrean prodissoconch is, that the umbos point posteriorly, as shown in fig. 2, pl. IV. This is contrary to all figures of developing dimyarians that I have seen, as in them the umbos point anteriorly.

In Ostrea indisputably the anterior adductor is first developed. In Cardium after Lovén (18), as mentioned by Huxley (8), also in the figures by Lovén of Modiolaria and Montacuta, in Pisidium after Lankester (17) and in Anodonta according to Schierholz (26), the anterior adductor is first developed. I have only found two exceptions to the general rule of the anterior being developed first. Lacaze-Duthiers, in his paper "Sur le Développement des Branchies" (15), figures a young *Mytilus edulis* with a posterior adductor, but no anterior. He notes, page 21, that he did not observe any anterior, and believes that the posterior adductor is first developed. He explains it, by the theory of arrested development, and compares this stage with the monomyarian Lamellibranchs, Ostrea and Spondylus. In Lovén's figure of Modiolaria, the anterior adductor is first developed, and, as it is so closely related to Mytilus, it seems possible that the distinguished authority, Lacaze Duthiers, overlooked the anterior adductor of Mytilus. Again, his comparison of the single-muscled stage of Mytilus with Ostrea, as a case of arrested development, will hardly hold, as Ostrea in the young is typically dimyarian, and therefore must be considered as a branch from a dimyarian root, not an ancestral monomyarian type. At any rate, if I am not mistaken, Mytilus must be considered as an exception to the general rule. The second exception I have found is Unio, where Huxley (9) in his "Anatomy of Invertebrated Animals," page 416, quoting Rabl (20) says, that the adductor muscle is first single and answers to the posterior adductor of the adult. Unio also seems to be peculiar in having its shell originate as an undivided membranous cuticula,[1] whereas the Lamellibranchiate shell is typically divided from its initial stages onward (see Horst (6 and 7), Lankester (17), Hatschek (5) and other authors). It is anomalous in having the primitive oral invagination on the dorsal aspect of the embryo and in having the byssus gland originate in the posterior end of the body. So many peculiarities exist in the embryo of Unio, it may, we think, in view of the evidence, be safely assumed that the development of the posterior muscle first, is not typical and, therefore, not incompatible with the theory that the anterior is typically first developed in Lamellibranchs.

In Ostrea the mouth and anus develop ventrally, the anal extremity of the intestine revolves dorsally, the anterior adductor develops, at a stage not yet determined the velum disappears. The mouth and œsophagus revolve dorsally and stop on the ventral side of the anterior adductor. The posterior adductor has developed apparently on the ventral side of the intestine. When one compares this with the figures and descriptions of the development of the above mentioned genera (excepting Mytilus and Unio), together with the anatomy of the adults, it seems that there is a close uniformity of plan. The genera mentioned are not numerous, but they have been taken from widely separate groups of Lamellibranchs. There is then strong evidence in favor of the development of the anterior adductor first in Lamellibranchs, as the typical mode, and the development of the posterior adductor later, after the intestine has revolved into place, from its early ventral position. This theory also easily explains the constant relative positions of mouth and anus to the two adductors in the adults of dimyarians, or to the single adductor, where only one exists, as in monomyarians. This first formed muscle being the morphological equivalent of the anterior muscle of adults which retain it, and the evidence for its typical uniform first appearance being so strong, since it is presumably of phylogenetic importance, I venture to suggest for this early stage the name *antemonomyarian*.

It is seen that I have so far described two distinct stages of development in the anatomy of the young oyster. First, a single-muscled stage, the antemonomyarian, fig. 1, pl. IV, pointing towards a problematical ancestor, which in the adult condition had only one adductor muscle, and that in the anterior portion of the body. The figure of this stage shows the early formed velum to be still existent, but it is not likely that the early antemonomyarian adult ancestor possessed a velum. It exists here presumably because of the lapping over of stages, due to concentration of development, which was noted as being most marked in early embryonic development. The second stage is the two-muscled stage, dimyarian, fig. 2, pl. IV, pointing to an ancestral adult form which had two muscles like the typical dimyarian. The shell which covers these stages is continuous in outline, and I have not made out any indication of change of form or structure to coincide with the change in the soft parts.

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[1] This same feature has been observed by Professor Brooks in Anodonta (2).

The next stage of a developing oyster is shown in fig. 3, pl. IV. This is a younger spat stage than has been previously figured, but shows great changes from the last, fig. 2, pl. IV. No trace of an anterior adductor was made out, but the posterior adductor can be seen just on the limits of the prodissoconch. Palps and gills were both seen and they have revolved dorsally from their previous ventral position. The gills are filamentous in structure, similar to those described in young Mytilus by Lacaze-Duthiers (15). In the specimen from which my figure was drawn, the outer limits of the filaments appeared to be free; but this may not have been the case, as it was difficult to see through the somewhat opaque shell. In fig. 4, pl. IV, drawn from a living oyster of a little older growth, the tips of the filaments are joined by a continuous, connecting membrane, similar to that figured in older stages of Mytilus by Lacaze-Duthiers (15).

The intestine wraps around the adductor muscle, as in fig. 2, pl. IV, and in older stages, fig. 18, pl. VII. The mouth parts have revolved dorsally, yet not through so great an angle from the position they formerly occupied in fig. 2, pl. IV, as seen in the adult, fig. 18, pl. VII. Professor Ryder (23) remarks, in speaking of a similar figure of a spat, which was taken from a later stage of growth, that the mouth opens downwards and not so directly forwards as in the adult; evidently it had not yet completed its upward revolution.

I succeeded in growing spat on glass slides, and excellent opportunities for studying them alive, under the microscope, were consequently at my command. When undisturbed and quietly feeding, the mantle stretches out to the margin of the shell on all sides, and even protrudes considerably beyond it. It moves actively, being constantly retracted and extended by the radial muscles[1] described by Professor Ryder (23). The marginal tentacles are also constantly in motion, being continually elongated and retracted. When elongated they are used with a tentative, feeler-like motion, and if irritated are capable of extreme prolongation and then exhibit great activity. The gills and palps move frequently and suddenly.

My studies corroborate Professor Ryder's figure of a specimen of a spat stage in all general points, except the convolutions of the intestine, which I did not succeed in making out.

During later stages of growth, the soft parts rapidly assume the positions which they occupy in the adult, fig. 18, pl. VII. The mouth parts are revolved towards the umbos, and the anus and adductor are revolved in the opposite direction, towards the free ends of the valves, until they attain a position at an angle of about forty-five degrees from the position which they had in the two-muscled stage, fig. 2, pl. IV.

In the dimyarian stage of the young oyster, fig. 2, pl. IV, the relative position of the axes of the body to the hinge axis of the shell[2] resembles an adult dimyarian Lamellibranch, fig. 15, pl. VII. The hinge is dorsal, free edges of the valves ventral, the mouth and anus lie at either end of the equal valves, so that the antero-posterior axis[3] is nearly parallel to the hinge axis. In the adult oyster, fig. 18, pl. VII, this relation is different. The mouth lies close up under the hinge line, marking this as the anterior end of the body. The free ends of the valves are at the posterior extremity, the gills lie on the ventral side, and the intestine on the dorsal.[4] The antero-posterior axis passes nearly through the umbos and centre of the valves and at an angle of about ninety degrees from the hinge axis. This revolution of the axes Ostrea is seen by comparing figs. 1, 2, and 3, pl. IV, and fig. 18, pl. VII.

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[1] In my fig. 3, pl. IV, the radial muscles were not seen; but they are readily seen in living specimens from which the shell has been partially broken away.

[2] The hinge axis refers to an ideal line drawn through the hinge area, and coinciding with the axis of motion of the valves, as shown in figs. 15–18 inclusive, pl. VII. My attention was called to the value of this line in considering the theory of the revolution of the axes, by Mr. B. H. Van Vleck of the Boston Society of Natural History.

[3] The antero-posterior axis, as shown in figs. 15–18, pl. VII, is considered as passing through the mouth and middle of the posterior adductor muscle and nearly or quite coinciding with the termination of the intestine.

[4] The fact that the umbos in the oyster are at the anterior end of the body has already been pointed out by several authors, and Hyatt (10) figures an oyster drawn over a clam to show their relations. Ryder (23), page 787, notes the rotation of nearly ninety degrees that must take place from my fig. 1, pl. IV, after Huxley, to bring about the adult relation of parts.

In other monomyarians, as Pecten and Anomia, the mouth lies close up under the umbos, which are in the median plane of the shell ; thus the relations of the axis to the shell are similar to those of Ostrea.

In heteromyarians, as Mytilus, Modiola, fig. 16, pl. VII, Perna, fig. 17, pl. VII, and Avicula, a distinctly transitional series may be studied, in which the relations of the axes are changed from what exists in the typical dimyarians, fig. 15, pl. VII, to what we find in the single-muscled group, fig. 18, pl. VII.

In the clam (*Mya arenaria*), fig. 15, pl. VII, the adductor muscles lie at either end of the longer axis of the shell, the mouth lies close up behind the anterior adductor, the anus overlies the posterior muscle, the umbos lie dorsally. The antero-posterior axis is nearly parallel to the hinge axis.

It is seen that in *Modiola plicatula*, fig. 16, pl. VII, the mouth and anterior adductor have revolved dorsally, so that they lie much nearer to the umbos than in the clam, fig. 15, pl. VII ; similarly, the posterior adductor and anus have revolved in the opposite direction, and occupy a position much further removed from the hinge line than in the clam. The antero-posterior axis lies at an angle of about 25° from the hinge axis.

In *Perna ephippium*, fig. 17, pl. VII, the mouth lies close up under the umbos, but the umbos are not in the median plane of the shell. No anterior adductor was found, but it probably exists in closely related species.[1] The posterior adductor and anus are still further removed from the hinge line than was the case with Modiola. The antero-posterior axis lies at an angle of about 50° from the hinge axis.

A revolution of the axes similar to that traced in oysters, and in the above serial groups, may be seen in *Mülleria lobata*, a widely separate genus. According to Adams (1) and other authors, it has two muscles when young ; but, when fully grown, one muscle.

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[1] Mr. Purdie, of New Zealand, in a paper (19) recently published, notes that *Mytilus latus* has no anterior adductor, while two otherwise closely related species *M. edulis* and *M. magellanicus*, have anterior adductors. In *M. latus*, the loss of the anterior muscle is accompanied by a movement of the one existing muscle inwards, nearer the central plane of the valves, where its mechanical action is more effectual.

The anterior muscle has disappeared, and the posterior, which is retained, lies in the middle lower portion of the shell, in a position closely similar to that of an oyster.[1]

The revolution of the axes in Lamellibranchs, relatively to the axis (hinge) of motion of the valves, is thus seen to be closely correlated with the reduction and final loss of the anterior adductor, together with the increase and final exclusive retention of the posterior.

THE SHELL.

The two valves of an adult oyster are together homologous with the single valve of adult cephalous molluscs. Both originate from the preconchylian gland, one as a single, the other as a paired organ. The adult shell of cephalous mollusca is termed a conch. Therefore, in view of its homology and double character, I suggest the name *dissoconch*[2] for the shell of an adult oyster, and similarly the same terminology is applicable to the adults of other Lamellibranchs.

The shell of oysters, at different periods of growth, presents striking dissimilarities. There are three well-marked stages of growth, as pointed out and figured by Professor Ryder (21):

(1) Prodissoconch, symmetrical fry stage; (2) Silphologic (spat) stage, flat left lower valve, and convex upper right valve; (3) Adult, flat upper right valve and concave lower left valve.

We will now consider the form and structure of the shell of the oyster, commencing with the earliest shell and continuing through the spat stages of growth.

The early prodissoconch as figured by Ryder (22), figs. 1–2, and others, is nearly discoidal, flattened into a straight line at the hinge area, fig. 1, pl. IV. The valves are convex, equivalvular, with concentric lines of growth, but farther apart ventrally, and closely underlying one another dorsally, so that as growth continues the centra are pushed forward, and lifted upward and outward until the close of the stage. By this method of growth, relatively high umbos are developed and the early straight hinge line is finally lost being superseded by one of a gentle curvature, fig. 5, pl. IV. At the close of the prodissoconch stage and before any spat growth has taken place the valves are deeply concave and nearly equal. The lower left valve is, however, somewhat larger and deeper than the upper right valve as seen in fig. 6, pl. IV. The umbos are always inclined upwards at about the same angle, and are directed dorsally as shown in above studies, fig. 2, pl. IV. They invariably point to the left of the observer, viewing them from above, when fixed to the object of attachment.[1]

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[1] This case is particularly interesting, as the change takes place much later than in the oyster. The two-muscled stage is not an embryonic one, but of a much older period of development. In Aetheria, a near ally, the two muscles are retained throughout life, in a partially revolved position.

[2] Διςσός, double; Κόγχη, shell.

The prodissoconch is, as described by Ryder (22, 24), homogeneous and laminar in arrangement, "not prismatic" as in the immediately succeeding stages of spat growth. It is composed of lime infiltrating an amorphous matrix of conchyolin, as may be seen by treatment with acid. One of the marked characters of the prodissoconch is the uniformity of shape and size found in different individuals. It has not the ostrean tendency to variability which is noticeable in later stages.

The height of the fully developed prodissoconch is about $\frac{1}{90}$ of an inch. It has already attained a size much greater than it had when first attached, according to Ryder's (22) figure of a recently attached individual.

The left attached valve turned over and viewed from the lower side is seen to be exactly like the right free valve in general appearance. It is not flattened nor are there other indications to mark where it was attached, so that this attachment is evidently of a very superficial and delicate nature.

Ryder (22) figures an oyster just after it has set, which seems very clearly to be effected by means of the mantle reflected over the edge of the lower valve. There is, in the later prodissoconch and spat stages, an organic conchyolin attachment of the shell itself, thus described by Ryder (24): "The cementing material seems to be the organic matrix of the shell which forms a perceptible layer on the outside of the valves, and which constitutes the epidermis or periostracum of the oyster." In the prodissoconch, as well as spat stage, the cement is so firm that, as Ryder says (22), the shell may be broken before it can be removed. To prove that this is an organic cement, if we put a drop of water on a dead, young shell, and allow it to remain a short time, it can be readily picked up on the point of a knife. Quite large spat may be removed when dead (*i. e.*, the organic matter inert) by soaking or boiling. Treatment with acid, on the other hand, does not loosen the hold of the shell. Quantities of young spat die during the summer, yet few dead shells are found on cultch, because soon after death the organic cement decays and is dissolved, and the shell falls off. Dead oyster shells exposed to water or weather sooner or later loosen their hold upon the stone or other object to which they had attached themselves when young. Professor Huxley (8) notes that the European oyster separates naturally from unfavorable objects of support; and that the separation takes place naturally at an early stage can be seen markedly in many fossil members of the family. Conversely, the calcareous plug of Anomia, which appears to be fixed to the object of support by a purely calcareous union, remains indefinitely after the death and separation of the individual to which it belonged. All our evidence is therefore in favor of the assumption that the cement by which the oyster is attached is wholly organic.

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[1] Professor Ryder informs me by letter that he has never seen an exception to this nor have I, though I have sought for umbos pointing to the right.

With the introduction of the spat stage, a fundamental histological difference arises abruptly in the structure of the shell. As we have stated above, the prodissoconch consists of lime infiltrating an amorphous matrix of conchyolin, but in the initial spat stage the first layer of shell is deposited in a "tessellated or prismatic" manner in a horny matrix, as described and figured by Professor Ryder (22, 24). Soon after the formation of the spat stage, the subnacreous, white, porcellanous layer begins to be deposited on the yellowish-brown, prismatic layer, first making its appearance as irregular blotches in the centre of the valve. These two layers continue throughout the rest of the life of the oyster, and together, though in disproportionate degree, build up the massive adult shell. The prismatic layer always remains thin, as may be readily seen by sections, or by treating an adult with acid, when the remaining conchyolin of the prismatic layer will separate from the overlying subnacreous layer like a dissected skin.

The protoconch of Owen, in Cephalopods, is the early shell which precedes the conch, or true shell. Professors Hyatt (13) and Brooks (3), consider the protoconch in cephalous molluscs as the univalve shell of the fully developed veliger, and probably derived from the periconch of Scaphopods.[1] It is seen from the study of Ostrea that the true shell, that which characterizes the adult, originates with the introduction of the spat stage. The earlier shell is strikingly different. It is the completed shell of the veliger antemonomyarian and dimyarian stages. It is distinctly the homologue of the protoconch and periconch. In the oyster, however, this shell is not single, but double-valved, and, therefore, deserves a distinct name, as it precedes the dissoconch or true shell. I suggest the name prodissoconch[2] or early double shell. A prodissoconch similar to that of Ostrea has been found in many allied genera.

The spat stage in *Ostrea virginica* as a whole is divisible into five stages. These five stages of growth are laid down one after another, and are more or less clearly marked in every regular growing, unworn, young specimen, fig. 7, plate v. To study these stages to the best advantage specimens should be sought growing in protected places, as the wear of sand and waves destroys their demarcation very rapidly. Some spat which I found in the inside whorls of dead Busycons, and others which I secured on artificial cultch of glass in drain pipes, and on inverted flower pots, retained the markings clearly.

The true larval or silphologic stages of Professor Hyatt (13) begin, according to the classification of that author, with the formation of what Owen called the apex of the conch, or true shell. It is shown above that the spat marks the beginning of the dissoconch (true shell) in Ostrea; therefore the stages into which it is divisible are here considered as the silphologic stages.

First silphologic stage (figs. 10, 11, plate v).—The spat growth begins along the lower margin of the prodissoconch valves figs. 2 and 6, pl. iv, and throughout life under normal conditions the most rapid growth is in this direction. The growth rapidly pushes up the sides of the valves, and between the hinge areas of the latter, fig. 8, pl. v, lifting them upwards, and separating them. A little to the right of the umbo of the lower left prodissoconch valve, as seen from above, in the initial stages of spat growth, is a notch which indicates the origin of the ligamental groove of the lower valve. This is seen clearly in fig. 9, pl. v.

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[1] Professor Brooks (2) says that the embryonic shell of Anodonta is at first a cup, covering what is to become the dorsal surface of the embryo and is, therefore, homologous with the embryonic shell of Gasteropods and he compares it closely to the first shell of Dentalium. See (16).

For the relations of the periconch to the protoconch, and the origin of the term periconch. See (13).

[2] Πρό, before; Δισσός, double; Κόγχη, shell.

It is necessary to describe the left and right valves separately. The upper right valve, fig. 10, pl. v, is directly continuous with the prodissoconch valve and follows the curve of that stage though in a lessening degree. It spreads out laterally on the hinge line in a descending curve. The lower left valve, fig. 11, pl. v, starts as does the upper, following the curve of the early valve. When this curve has been followed for an extremely brief period, the valve suddenly flattens, and becomes closely related to the surface of attachment. The result of this, is that a slight groove runs around the border of the spat valve, beyond which it is abruptly continuous with the flat later growth, as has already been mentioned by Professor Ryder (23). I have, however, to note a peculiar and significant exception. Sometimes instead of becoming flat and closely related to the object of attachment, the spat valve of this stage is continuously curved throughout its extent, and not at all flattened. It then closely resembles the upper valve of the same stage in shape. This curved shape is held, as far as I have made out, only on rough objects of attachment. Seeking for such material on rough stones and shells, one will always find some valves more or less curved in their earliest stages. This is very interesting, as showing the modifying influences of environment, on a very young stage where heredity might be supposed to fashion the form, with overpowering force.

Second silphologic stage (figs. 12, 13, pl. vi).—In the second stage the upper valve is in form a continuation of the first stage. The lower valve when flat begins to spread out over the object of attachment by wing-like extensions of its anterior margins. In the lower valve this stage commonly makes a shoulder, on its anterior border by its increased growth, where it comes in contact with the outer limit of the first silphologic stage, fig. 13, pl. vi. Similar shoulders also mark the periods of growth of later stages in the lower valve. The lower valve may remain concave throughout this stage as in the first silphologic stage. The shells during the first two stages are characteristically even and rounded in outline.

Third silphologic stage (fig. 14, pl vi).—The upper valve in smooth regular growing specimens still holds the simplicity of outline and conforms closely to the angles of curvature laid down in the outlines of the first silphologic stage. The convolutions and distortions common in oysters do not often originate before the close of this stage. The lower valve spreads out over the object of attachment, and the leaf-like layers of deposition are seen as viewed from above, spreading beyond the limits of the hinge line, (see fig. 14, pl. VII). I have not seen an oyster in which this stage remained curved as described in the two previous stages.

Fourth silphologic stage.—This stage and the fifth are more difficult to characterize than the preceding ones, as so much variation occurs in different specimens. The upper valve in regular growing specimens frequently departs from the angle of the anterior marginal line which is handed down from the first silphologic stage and spreading out laterally becomes more wing-like on the margin than any earlier stages, fig. 14, pl. VI. These wing-like productions of the spat growth were pointed out and figured by Professor Ryder in a description of the spat stage (21, 24). In this stage the shells often change the direction of growth and the umbos may be revolved so that they point in the opposite direction from that which they would otherwise have normally assumed.[1] The lower valve still remains flat and throws out extensions of its margin over the object of attachment as shown in Ryder's figures referred to and my fig. 14, pl. VI.

Fifth silphologic stage (fig. 7, pl. V).—This may be described as similar to the fourth stage, and it is the last of the spat stages of growth. The end of this stage is very marked and may commonly be seen in adult oysters as the limits of the smooth, rounded convex area at the apex of the conch, and is often figured in living and fossil oysters.

The shell has, up to this time, normally, the rotundity characteristic of the earlier spat stages; but afterwards, with certain exceptions it assumes the true ostrean form. If the oyster continues to grow closely on the object of attachment, the lower valve remains flat and the upper curved as before, fig. 7, pl. V, but no more distinct stages are indicated. When the shell projects over the object of attachment the lower valve becomes concave and the upper flat, as in adults, as described by Brooks (4) and Ryder (21). If this occurs before the close of the fifth silphologic stage it does not prevent the demarcation of those stages in both valves.

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[1] Professor Ryder (25) notes this change in direction of growth.

REMARKS UPON THE ADULT AND ALLIED GENERA.

Professor Ryder (21) mentions that he has found prodissoconchs like that of *O. virginiana* in several species and thinks it is probably characteristic of the family. I have found prodissoconchs precisely like that of *O. virginiana* in other living and many species of fossil oysters, in several species of Exogyra and Gryphæa, from the Jurassic and Cretaceous, and in some related genera.

In oysters as far back as the Jurassic, species have been found with the spat growth marked off into five stages similarly to *Ostrea virginiana*, showing that the series of stages found in our species already existed at that early date in some members of the family.

It is not held that the spat stage is in all forms divisible into five stages; but only that it is a persistent characteristic found in some species. In all oysters, living and fossil, the silphologic (spat) period is more or less clearly marked. In species which are plicated or otherwise peculiar, the adult characteristics do not often appear before the close of the spat stage.

The genus Gryphæa is described as free or attached in the young stages, yet I have not been able to find a species in which it was free at a very young stage. All have a flat area in the lower valve and a curved in the upper, corresponding to the attached spat stage of the oyster. *G. arcuata* of the Lias would be commonly considered as free, yet I have found well preserved specimens in which the lower valve is flat at the apex, where it was attached when young, and correspondingly the upper valve has a small convex area at the umbo, as noted by Sowerby (27).

The area of attachment in many species of Gryphæa is uniform in size, indicating that the shell dehisced at a very definite period from the object of attachment. In fact, highly arcuate forms must have separated early, as the form could not have been developed, unless the shell was free. Other species were attached for a very variable period, as is seen by the differing size of the flat area of the lower valve and corresponding curved area of the upper. This is well shown in any large collection of the European form of *Gryphœa vesicularis*.

Exogyra, also, is said to have been free or attached; and here the case is somewhat more complex. Take the typical *E. costata* of the Cretaceous, for example. Specimens are found in which a flat area at the apex of lower valve distinctly shows them to have been attached when young, but rarely are adults found with the object of fixation still clinging to them, showing that as in Gryphæa, and many oysters, they separated naturally. Other specimens are found, which, upon most careful examination, show no flattened area on the lower valve. I have already noted that Ostrea may in its early silphologic stages be attached, and yet not conform to the object, or flatten at all, so that if it could have separated at the end of this period, and lived, the adult would show no sign of early fixation. This is just what I think took place in specimens of Exogyra which show no flat area. In such specimens there is no proof that they were not fixed during the young stages; but merely that they dehisced before the shell conformed to the outline of the object of support.

In the Ostreadæ there is a striking peculiarity of the adult which I believe not to have been thus far noticed. The two valves are unequal, one being concave and the other flat; but they are not only unequal, they are very dissimilar, as different as if they belonged to distinct species in what would be considered typical forms. As examples we may take *Ostrea edulis* of Europe, *O. compressirostris*, Eocene, of this country, *Exogyra costata*, Cretaceous. In these, the lower valves are plicated, and the upper smooth, and regular-growing, without plications. The examples could be multiplied extensively, but these suffice to give my meaning. This is a highly interesting feature, as it is evidently a case of inherited or acquired characteristics, finding very different expression, in the two valves of a group, belonging to a class typically equivalvular. As might be expected, variations from this rule are common, as in *Ostrea marshii, O. larva*, etc., where the valves are closely alike. Dissimilarity seems, nevertheless, to be the rule. *Ostrea virginiana* is a good example of a form in which the upper valve sometimes reflects the form of the lower, but this is commonly departed from, and proves the rule, by dissimilarity being its typical preponderating form.

In adult *Ostrea virginiana*, the left valve is concave, and the right valve is flat, when growing naturally, the left valve being lowermost. Professor Ryder notes that the same relative shape is held by oysters which grow vertically in crowded beds. Oysters frequently attach themselves to the lower side of objects, so that the left valve is uppermost, and right valve lowermost, the reverse of the common position, fig. 19, pl. VII, and here again the normal relative shape of the valves is maintained, the left valve concave, the right flat. The oyster is such a variable form that this fact has a significance. We should expect it to be specially susceptible to varying conditions of environment; yet here strikingly different positions find no change in the resulting form. This is evidence in favor of Professor Hyatt's theory that the *attached*, *supported* valve of fixed bivalve shells is the larger (11) but contrary to his theory of gravitation (11), according to which the lowermost valve should be thick and concave which is seen not to be the case in reversed specimens of oysters. Whatever may have been the cause of the typical form of the group, gravity is insufficient to modify greatly the form of a modern individual.

NOTE.—Since the corrected proof of this paper went to press my attention has been called to a paper by Dr. Benjamin Sharp, Remarks on the Phylogeny of the Lamellibranchs, Proc. of the Acad. of Nat. Sci., Phila., March, 1888, pp. 121–124. In it he presents a mechanical theory for the loss of the anterior and retention of the posterior adductor muscle in Lamellibranchs, which is quite similar to that presented here in the revolution of the axes.

LIST OF PAPERS QUOTED AND REFERRED TO IN THE TEXT.

1. H. and A. ADAMS. Genera of Mollusca. London, 1858, Vol. II.
2. W. K. BROOKS. Embryology of the Fresh Water Mussels. Proc. Am. Assoc. Adv. Sc., 1875.
3. W. K. BROOKS. The Affinities of the Mollusca and Molluscoidea. Proc. Bost. Soc. Nat. Hist., Vol. XVIII, 1876.
4. W. K. BROOKS. Development of the Oyster. Johns Hopkins Univ. Biol. Lab. Studies, I, 1879–80. Reprinted from the Rep. of the Commissioners of Fisheries of Maryland, 1880.
5. B. HATSCHEK. Ueber Entwickelungsgeschichte der Teredo. Arbeiten aus dem Zool. Inst., Wien, Vol. III, 1881.
6. R. HORST. Contribution to our Knowledge of the Development of the Oyster, O. edulis. Bull. U. S. Fish Com., Vol. II, 1882. A translation from the Dutch by J. A. Ryder.
7. R. HORST. The Development of the Oyster. Rep. U. S. Fish Com. 1884. Washington, 1886. Translated from the Dutch by Herman Jacobson.
8. T. H. HUXLEY. Oysters and the Oyster Question. English Illustrated Magazine, Oct. and Nov., 1883. Partly reproduced by J. A. Ryder in his paper No. 23.
9. T. H. HUXLEY. Anatomy of Invertebrated Animals.
10. ALPHEUS HYATT. Guides for Science Teaching. The Oyster, Clam and other Common Mollusks. Boston, 1880.
11. ALPHEUS HYATT. Transformations of Planorbis at Steinheim, with Remarks on the Effects of Gravity upon the Forms of Shells and Animals. Proc. Am. Assoc. Adv. Sc., Vol. XXIX, 1880.

12. Alpheus Hyatt. Larval Theory of the Origin of Tissue. Proc. Bost. Soc. Nat. Hist., Vol. xxiii, 1884. See Proc. Bost. Soc. Nat. Hist., Vol. x, pp. 302–303, Feb. 21, 1866.

Also, Parallelism between the Individual and Order in Tetrabranchiate Cephalopods. Mem. Bost. Soc. Nat. Hist., Vol. i, 1867.

13. Alpheus Hyatt. Values in Classification of the Stages of Growth and Decline, with Propositions for a new Nomenclature. Proc. Bost. Soc. Nat. Hist., Vol. xxiii, 1888. An abstract in Science, Vol. ii, No. 260, p. 41.

14. Robert T. Jackson. Catching Fixed Forms of Animal Life on Transparent Media for Study. Science, Vol. xi, No. 275, p. 230, May 11, 1888.

15. H. Lacaze-Duthiers. Mémoire sur le Développement des Branchies des Mollusques Acéphales Lamellibranches. Ann. des Sc. Nat., ive serie, T. v, 1856.

16. H. Lacaze-Duthiers. Histoire de l'Organisation et du Développement du Dentale. Ann. des Sc. Nat., ive serie, T. vi, 1856. Continued in Vol. vii, 1857.

17. F. Ray Lankester. Contributions to the Developmental History of the Mollusca. Phil. Trans. Vol. 165, Part i, 1875.

18. S. Lovén. Bidrag till Kannedomen om utvecklingen af Mollusca Acephala Lamellibranchiata. Kongl. Vetenskaps Akademiens Handlinger. Stockholm, 1848. Translated into German by Dr. C. H. Creplin in Archiv fur Naturgeschichte, Vol. xv, i, 1849.

19. Alex. Purdie. The anatomy of the Common Mussels. Colonial Museum and Geol. Survey Dept., Wellington, New Zealand, 1887.

20. C. Rabl. Ueber die Entwickelungsgeschichte der Malermuschel. Jenaische. Zeitsch., Vol. x, 1876.

21. John A. Ryder. An Account of Experiments in Oyster Culture and Observations relating thereto. Rep. Maryland Fish Com., 1881.

22. John A. Ryder. On the Mode of Fixation of the Fry of the Oyster. Bull. U. S. Fish Com., Vol. ii, 1882.

23. John A. Ryder. On the Metamorphosis and Post-larval Stages of Development of the Oyster. Rep. U. S. Fish Com., 1882. Washington, 1884.

24. John A. Ryder. A Sketch of the Life-history of the Oyster. Published in Dr. C. A. White's Monograph, entitled " A Review of the Fossil Ostreidæ of North America, and a Comparison of the Fossil with Living Forms." U. S. Geol. Survey, Fourth Annual Rep., 1882–83.

25. John A. Ryder. A Contribution to the Life-history of the Oyster, in "The Fisheries and Fishery Industry of the United States." Section 1, 1884, pp. 711–758.

26. Carl Schierholz. Zur Entwickelungsgeschichte der Teich- und Fluss-Muschel. Zeit. fur Wiss. Zool. Vol. xxxi, 1878, pp. 482–484.

27. G. B. Sowerby. The Genera of Recent and Fossil Shells, Vol. ii, London, 1821–26.

EXPLANATION OF PLATES.

All figures of oysters, except Fig. 1, are of *O. virginiana* Lister. All the figures, with the exception of Fig. 1, were drawn directly from nature. The figures of microscopic specimens were copied from camera lucida drawings. All oysters, excepting Figs. 1, 7 and 8, were collected at Buzzards Bay, Massachusetts. For Fig. 19 I am indebted to the kindness of Mrs. J. W. Elliot. Figs. 2, 5, 6 and 14, were drawn by Mr. F. W. Cobb. All other figures were drawn by the author.

PLATE IV.

Fig. 1.[1] Young European oyster (*O. edulis* Linn). Antemonomyarian stage, viewed from the left side. *a. ad*, Anterior adductor, which alone exists at this stage; *m*, Mouth; *œ*, Œsophagus; *a*, Anus; *i*, Intestine; *st*, Stomach; *ll*, Left lobe of the liver; *v*, Velum; *rs*, *ri*, Superior and inferior muscles, which retract the velum into the shell, *sh*. The shell is in its early prodissoconch stage; the hinge, *h*, is straight.

Fig. 2. Dimyarian stage, viewed from the right side, as when attached. *a. ad*, Anterior adductor muscle; *p. ad*, Posterior adductor; *m*, Mouth; *œ*, Œsophagus; *pl*, Palps; *a*, Anus; *g*, Gills. The shell has completed the prodissoconch stage, and a slight spat growth, *s*, exists along the lower margins of the valves. The straight hinge line of fig. 1 is lost. The developed umbos point posteriorly. Magnified about 130 times.

Fig. 3. Anatomy of very young spat, viewed from the right side. *p. ad*, The single adductor, the morphological equivalent of the posterior adductor of fig. 2; *m*, Mouth; *pl*, Palps; *a*, Anus; *g*, Gills; *mt*, Margin of mantle. The lines of growth of the shell are shown in the left valve of the prodissoconch, *p*, but are omitted in other parts of the shell for the sake of clearness; *p'*, Right valve of prodissoconch; *s*, Right valve of the spat growth. Magnified 120 times.

Fig. 4. Margin of a living gill from a little older stage of oyster than fig. 3.

Fig. 5. Fully developed prodissoconch, viewed from the right side, growing on a glass slide. *l*, Left valve; *r*, Right valve. Magnified 130 times.

Fig. 6. Prodissoconch, viewed from the anterior end. *l*, Left valve; *r*, Right valve; *s*, Spat growth, which has begun along the margin of the prodissoconch valves. Magnified 130 times.

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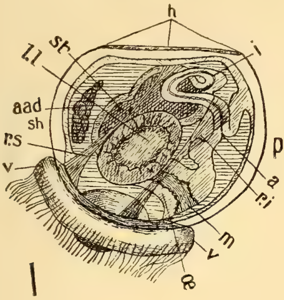
[1] After Huxley, reduced one-half from his figure, published in Eng. Ill. Mag. See No. 8 and again in Bull. U. S. Fish Com. Rep., No. 23.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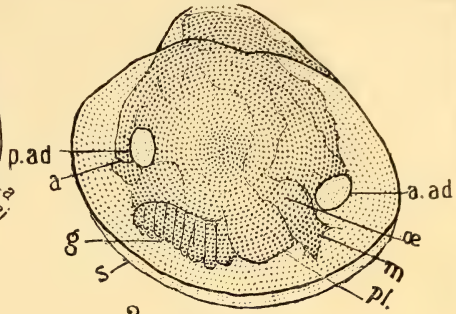
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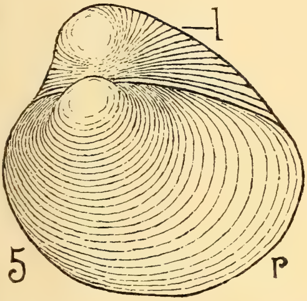

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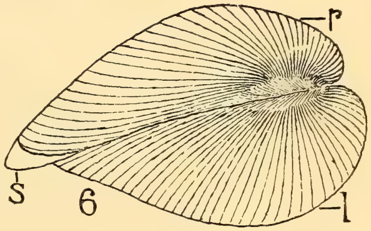

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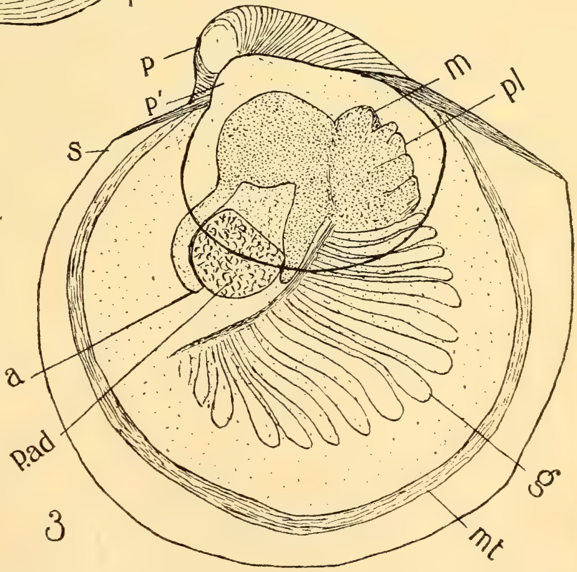
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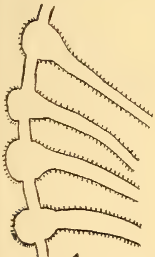

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Jackson, Development of the Oyster.

PLATE V.

Fig. 7. Young oyster from the side of a vessel in Provincetown, Massachusetts, showing five silphologic stages of growth of the right valve (1*s*, 2*s*, 3*s*, 4*s*, 5*s*). The first two stages were drawn from a younger specimen as they were worn off in the specimen in hand. Life size.

Fig. 8. Young oyster viewed from the hinge end. *p*, Prodissoconch; *lv*, Left valve; *rv*, Right valve; *s*, Early spat growth. The left valve has not yet flattened to the object of attachment.

Fig. 9. Tip of left valve of an oyster from inside whorls of a dead Busycon, where it was preserved from all eroding action. *p*, Prodissoconch; *s*, Spat growth; *l*, Ligamental groove; *f*, Flange-like extension of margin of the shell over the object of fixation; *b*, Border of shell proper, exclusive of flange. Magnified seventy-five times.

Fig. 10. Young oyster growing on glass, viewed from right side, showing *p*, Left and right valves of prodissoconch; 1*s*, First silphologic stage.

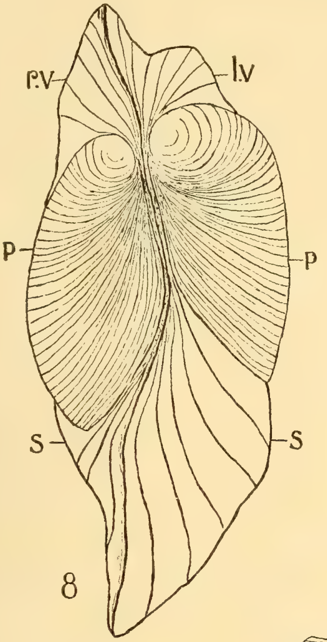
Fig. 11. Same specimen as fig. 10, viewed from left side through the glass on which it was attached. *p*, Left valve of prodissoconch; 1*s*, First silphologic stage. Figs. 10 and 11 magnified thirty-six times.

PLATE VI.

Fig. 12. Oyster growing on glass, viewed from the right side, showing *p*, Left and right valves of prodissoconch; 1*s*, 2*s*, Limits of first and second silphologic stages.

Fig. 13. Same specimen as fig. 12, viewed from the left side through the glass to which it was attached. *p*, Left valve of prodissoconch; 1*s*, 2*s*, Limits of first and second silphologic stages; *l*, Margin of left valve beyond which the right (upper) valve extends. Figs 12 and 13 magnified eighteen times.

Fig. 14. Oyster growing on glass, viewed from right side. *p*, Left and right valves of prodissoconch; 1*s*, 2*s*, 3*s*, 4*s*, Limits of first, second, third and fourth silphologic stages of right valve. Magnified six times.



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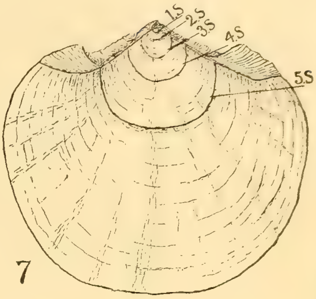
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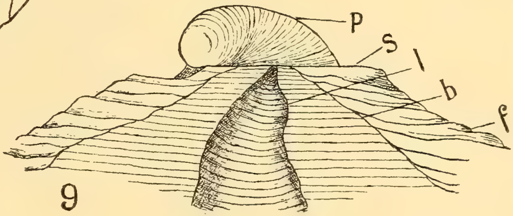

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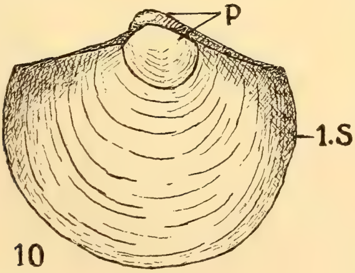

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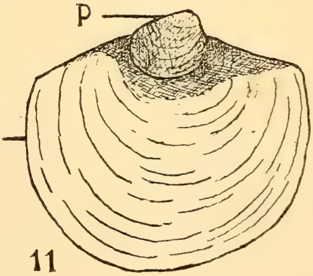

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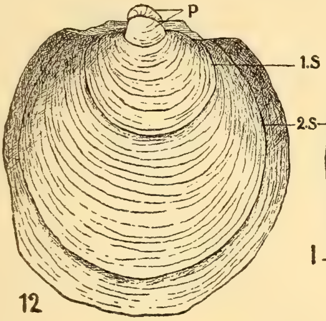
Jackson, Development of the Oyster.



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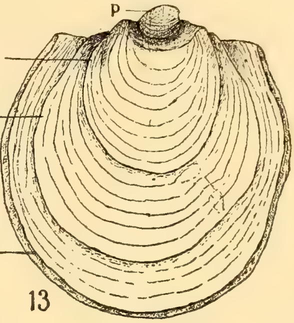

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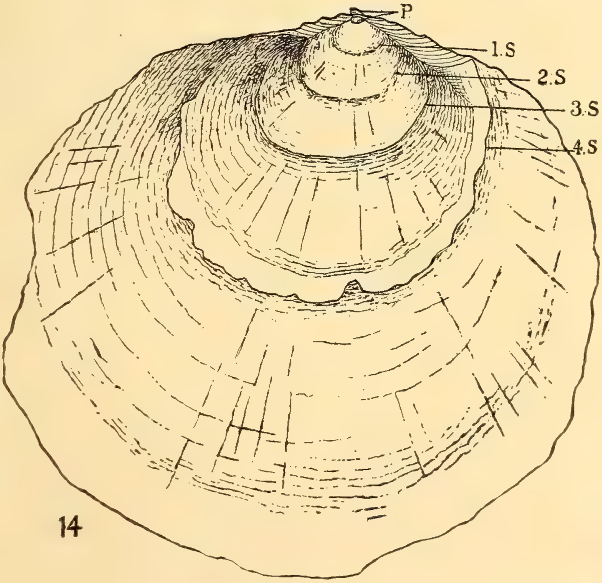

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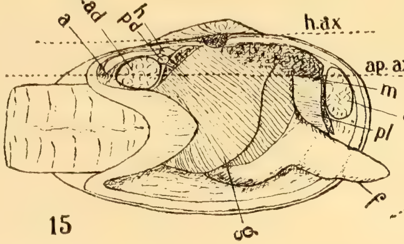
Jackson, Development of the Oyster.

PLATE VII.

Revolution of the Axes. Fig. 15. *Mya arenaria.* Fig. 16. *Modiola plicatula.* Fig. 17. *Perna ephippium.*

Fig. 18. *Ostrea virginiana.* *h, ax*, Hinge axis, the axis of motion of the valves. *ap. ax*, Antero-posterior axis, drawn through the mouth and middle of the posterior adductor muscle; *a. ad*, Anterior adductor; *p. ad*, Posterior adductor; *m*, Mouth; *pl*, Palps; *a*, Anus; *g*, Gills; *pd*, Pedal muscles; *f*; Foot; *b*, Byssus; *h*, Heart.

Fig. 19. Two oysters fixed to the same object of attachment, one growing naturally with the left valve lowermost, the other in a reversed position with the right valve lowermost. The left hand specimen is growing in the normal position with *r*, the right valve, uppermost and *l*, the left valve, lowermost. The right hand specimen is growing in a reversed position with *r*, the right valve, lowermost, and *l*, the left valve, uppermost. Life size.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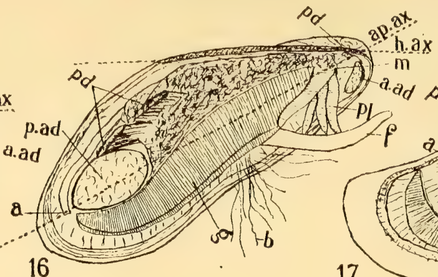
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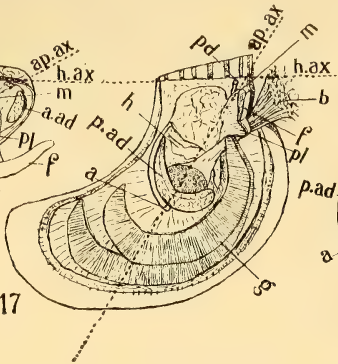
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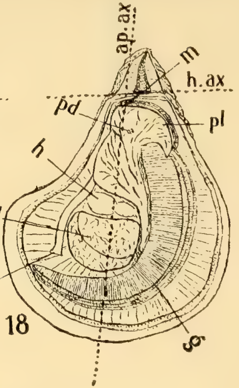
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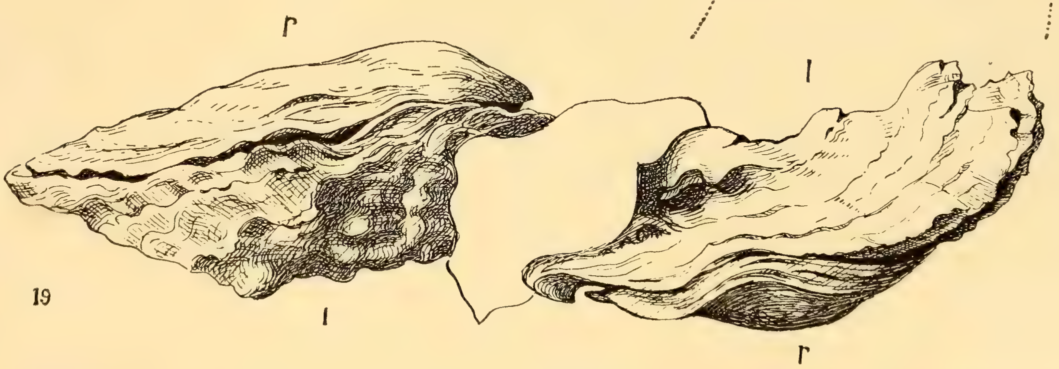

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Jackson, Development of the Oyster.

General Meeting, April 18, 1888.

Vice President, George L. Goodale, in the chair.

Professor Goodale read for the author, the following obituary.

SKETCH OF THE LIFE AND SERVICES TO SCIENCE OF PROF. SPENCER F. BAIRD.

BY ALPHEUS HYATT.

It would not be possible for me to have complied with the request of the President of this Society to prepare a short notice of a life so full of solid results as that of Professor Baird, or to have written anything approximating to what I considered to be really due to his memory, if I had not been assisted by several obituary notices, and by the admirable biographical sketch and complete bibliography of all his works published by Prof. G. Brown Goode during his lifetime.

He was born at Reading, Pennsylvania, in 1823, and graduated at Dickinson College in 1840, at the early age of seventeen. He studied medicine for a time, but never practised. His natural history studies were begun in earnest soon after he had left college and were thenceforth the principal occupation of his existence. He became an active and zealous student of plants and animals and acquired, by his unwearying efforts during these early years, not only a large collection and great familiarity with characters and habits of organisms, but a store of health and strength, which enabled him to stand the strain of the intense intellectual labors of his mature life.

His first paper was published in 1843; in 1845 he was appointed Professor of Natural History in Dickinson college, and in 1848 received from Professor Henry the first grant made by the Smithsonian Institution in aid of scientific exploration and field research. This was given to assist him in the exploration of the bone caves and local natural history of southeastern Pennsylvania. In 1850 he was appointed, by Professor Henry, assistant secretary of the Smithsonian Institution and entered upon those public duties, which led to greater results, so far as the material foundations of science in this country are concerned, than have been so far actually accomplished by any other man.

The life of investigation begun with such energy was not discontinued when he entered upon the harassing and absorbing duties of his public post. These duties would have entirely filled the time of a man less endowed with physical power and less gifted with the divine thirst for knowledge drawn from the untrodden fields of original research. The list of his publications, prepared by Professor Goode, shows unremitting devotion to systematic zoology until the year 1869, a period of nineteen years.

He was placed by Professor Henry in charge of the organization and superintendence of the Smithsonian department of exchanges, and built up and developed that vast system of communication between scientific societies and individuals, which has been and is now one of the most effective instruments of scientific progress ever devised. He was also placed by Professor Henry in charge of the department of Scientific Exploration which taxed to the utmost all his powers as a man of science and a manager of men, and must have occupied a large proportion of his time. In the performance of these duties it was essential not only to select suitable persons to accompany surveys and do the work in the field, but to persuade the leaders of expeditions that such persons were essential, and then to secure favorable legislation from congressmen.

He also had charge of the natural history collections of the Smithsonian, which had been started by the deposit of his own collections, and which daily grew under his fostering care, and by accessions flowing in from the various government explorations.

His official occupations would have been ample excuse for not taking part in making known the results of explorations, but this was not his own view of duty. It is not, in our opinion, his least service to science, that he has set before future generations the example of a man, who not only carried on the duties of several bureaus faithfully, but, for nineteen years of this time, steadily pursued his investigations, and actually published works, which have made his name an essential part of the history of original research in North America.

His publications upon vertebrata are standard books and will probably remain such for many years to come. They have gained from such men as Stejneger, Allen and Ridgway the most unqualified praise for method and accuracy. Stejneger goes so far as to say, that Baird's methods really began and established an era in the history of vertebrate zoology in North America, and that he led in respect to systematic work both in this country and in Europe, founding, what he has called, the Bairdian school of systematists.

When he entered the vortex of national life at Washington the minds of leading men were filled with plans for making the vast western possessions of the United States available for settlement. Exploration and the publication of the resources of the different parts of the country and the building of railroads were the obvious means for the attainment of this object. Professor Baird had the penetration to see that the opportunity of science lay in establishing a claim to usefulness in connection with these efforts for the enlargement of the nation. It was in large measure due to his delicate management and untiring zeal, that collectors were employed upon every expedition sent out by the government, whether to the west or to foreign countries. After the return of these expeditions the publication of the results was urged and secured, and at last it came to be recognized, that researches in geology, palæontology, botany and zoology and their publication were necessary adjuncts of a complete exploration or survey.

To these expeditions, and to his unwearying sympathy, constant helpfulness and advice, we can trace the education of an army of collectors and scientific men who have since done noble service for science. He gave his influence and the benefit of his greater experience to the men who founded the different geological surveys, and was thus more or less intimately connected with their early history.

In 1879 Congress was induced to recognize the need of collecting and publishing descriptions of the aboriginal monuments and remains of the United States, and made the first annual appropriation of $20,000 for that purpose. This grant was given directly to the Smithsonian, and Professor Baird, who was then Secretary, appointed Major Powell to be director of the new department. Thus the Ethnological Bureau was founded and its first four reports by Major Powell, volumes of hundreds of pages, profusely illustrated, have already appeared.

After his appointment to the Smithsonian, that institution began to support a Museum, and his collections and those gathered under his superintendence were all it possessed until 1857, when the regents finally agreed to receive the collections of the Wilkes' expedition then stored in the patent office. Congress granted a small sum for their maintenance, $4000 a year, until 1870, and then, after having been continually solicited by Henry and Baird, they at last granted the sum of $20,000 per annum. It was not, however, until 1876, that Congress really recognized the Mational Museum by making an annual appropriation for its support, and in 1879 Congress was induced to grant $250,000 for the erection of a separate building for its use. This was the most important step in the history of the Museum and was the direct result of the Smithsonian Exhibit at the Centennial Fair. The main argument for the erection of this building, and that which was used with greatest effect in procuring the necessary appropriation, was the obvious need of preserving and displaying the enormous collections accumulated mainly through Professor Baird's management in Philadelphia.

Though established by Congress in connection with the collections of the Wilkes' expedition under the title of the National Collection of Curiosities, the National Museum had had no life, and no existence as a Museum, until taken into the much larger collections of the Smithsonian. This institution had supported collections for seven years; and, after the reception of the Wilkes' expedition collections it still continued, for thirteen years more, to supplement the inadequate annual appropriations made by Congress. Thus the existence of the National Museum was preserved for twenty years at the expense of the Smithsonian. The credit of founding the National Museum must, therefore, be accorded to Baird, and to the institution of which he was an officer.

This statement of events indicates a long term of struggles with harassing difficulties and arduous labors, which can never be recorded. There was, as there always is in front of all great efforts, abundance of criticism and opposition of a more or less reasonable or unreasonable kind from scientific men, which had to be met and overcome. Though possessing the sympathy of a few congressmen the mass of legislators were at first indifferent or inimical, and behind them lay a sovereign population disposed to applaud opposition to the expenditure of money for the support of the apparently useless aims of science.

The resources of the Smithsonian were employed unremittingly in every way to overcome these difficulties, and Henry and Baird virtually kept school for the nation. They distributed scientific documents and what we might call scientific tracts, and constantly worked for the education of Congress and the people, until the name of the Smithsonian penetrated into every corner of our vast territory, and won respect for its agents and objects, and finally became intimately associated with our national reputation both at home and in foreign lands.

The United States Commission of Fish and Fisheries, which has attained such a high reputation for its efficiency as an economical and scientific undertaking, stands in the same category with the National Museum, and owed its origin, character and success to Professor Baird. As an illustration of the motives which influenced him, the author of this sketch has treasured the memory of an interview at Wood's Holl, in which he expressed himself without reserve as devoted to the scientific side of the Commission, to the encouragement of researches upon the marine flora and fauna, and to the laboratory work of the Woods Holl station. It must be remembered, that he never derived any benefit from this position, getting neither increase of salary nor opportunities to follow out researches of his own. Additional labor in the bureau was his share and this at a time, when he was, as is well known to many persons, carrying on by the aid of his helpful daughter the scientific editorship of the Harpers' Brothers' periodicals, and of their "Annual Record of Science and Industry" in order to add to his income.

In connection with the Commission, and by means of its vessels and laboratories, many of our ablest naturalists have carried on investigations upon the marine flora and fauna along the whole coast of New England, collecting and describing the animals and plants until they have become fairly well known. With regard to the economic triumphs and results, we cannot do better than to quote the closing words of Dall's interesting address at the Baird Memorial meeting held in Washington, Jan. 11, 1888.

"Whether germane to the subject of scientific research or not, the most narrow specialist can hardly grudge an allusion to the grandeur of the methods by which the food supply of a nation was provided, hundreds of rivers stocked with fish and the very depths of ocean were repopulated. Typically American, we may call them, in their audacity and their success. The fishery boards of foreign countries, first quietly indifferent, then loudly incredulous, in due time became interested inquirers and enthusiastic followers. In a few years we may fairly expect to see the food supply of the entire civilized world materially increased, with all the benefits which that implies, and this result will, in the main, be owing to the unremunerated and devoted exertions of Spencer F. Baird."

Professor Baird succeeded Professor Henry in 1878 as secretary of the Smithsonian and for a few years he carried on successfully this institution, the National Museum and the Fish Commission, any one of which would have been sufficient to fill his time and his mind. All his biographers unite in representing this increased tax upon his energies to have been the immediate cause of the sickness which ultimately resulted in his death.

Professor Baird was always more or less in correspondence with the officers of this Society, and at his solicitation, during Mr. Scudder's time as secretary, the Society joined the Smithsonian in sending out several expeditions for the collection of birds. He exercised during Dr. Brewer's life a direct influence upon the administration of the Society, so far as the extensive collections of birds and eggs were concerned, and these collections owe many specimens to his liberality. During his visits to this city, he usually spent part of a day with us and walked through the Museum. He invariably showed on these occasions that he had kept in mind the former condition of the collections, and almost always had some suggestions or friendly criticisms to make, which exhibited an active interest in what was being done.

Professor Baird was also much interested in the Annisquam marine laboratory, and every year during the last four or five years of his life urged me, by personal interviews and by letters, to use my influence to have the laboratory transferred to Wood's Holl and brought into more intimate association with the Fish Commission. A friend of his had bought land near the Fish Commission buildings, and held it for the benefit of any educational institutions which might be induced to build laboratories there for the use of students. This scheme deserved to succeed, but the times and the impecunious condition of our educational institutions made it impracticable. These institutions either did not have students of zoology or were too poor to respond to the generous offers made by the Commissioner of Fisheries and his friends ; and the Annisquam Laboratory, though it would have gained greatly by association with the Fish Commission, was also hampered by pecuniary disabilities. It is greatly to be regretted, that the plan could not have been held open indefinitely until opportunities for seaside work would have been required by the Colleges. This event is not far distant, and it would be as greatly to the advantage of the government, as to the associated institutions themselves, if Woods Holl should ever become a centre of research.

The Fish Commission has been a direct aid to the collections of the Society. Opportunities for procuring New England fishes, and also New England Invertebrata, especially Porifera, were freely given to the curator by the officers of the commission, and the collections then made are in our Museum.

The first efforts of the Teachers' School of Science were much facilitated by the kindness of Professor Baird, who allowed the curator to take away all the waste materials of the shallow water dredging expeditions of the Fish Commission and thus hundreds of specimens were provided in 1871, for the large classes of the school and afterwards given away to teachers. The curator also received in common with many other scientific men opportunities for study and research at Woods Holl, which were of great value to him personally. In fact, the work of the Fish Commission, like that of all other departments conducted by this remarkable man, helped the interests of science and of scientific men in every possible way.

Professor Baird, though not a genius in the sense of having made great discoveries, was nevertheless a leader among the systematists of his time, and founded what has been called by eminent authorities, the Bairdian school of systematic zoology; though not a professional teacher, he really taught successfully in the greatest of schools, that in which the legislators of a nation and their constituents were the students; though not brilliant in conversation or eloquent as a speaker, he yet induced Congress to follow his lead and adopt his suggestions for upwards of thirty years and steadily gained in power and influence during that time; though not the organizer of the Smithsonian, he loyally seconded his principal, and made that institution far more powerful for good than it could have otherwise become; though not a geologist, his work, care, and advice greatly assisted the men who laid the foundations of the geological surveys; though only a student well versed in Ethnology, it was largely his work which opened the way and finally led to the establishment of the Ethnological Bureau. Upon this already magnificent pedestal stand the giant figures of the two institutions we owe to him, the National Museum, and the Commission of Fish and Fisheries, backed by their collections, buildings and publications. The grandeur of these results, accomplished by a man whose modesty and want of self-assertion marked every thought and deed, will not fail to fill a large space in history, and attract greater reverence as time increases the perspective; and future generations will accord to Baird's memory, fame and honors commensurate with their national importance and usefulness.

Prof. Charles S. Minot gave an account of a new apparatus for cutting microscopical sections automatically. He accompanied his paper by demonstrations.

The following paper was read by title: On the Entomophthoreæ of the United States. By Roland Thaxter. (See Memoirs, Vol. IV, No. 6.)

SECTION OF ENTOMOLOGY, APRIL 25, 1888.

Mr. S. H. SCUDDER, in the chair.

The following paper was presented:

THREE SPECIES OF HEMEROBIUS FROM CHILI.

BY H. A. HAGEN.

1. Hemerobius signatus.

Hemerobius signatus Hag., Syn. N. Am. Neur., p. 322.

Long. c. al. 7 mm.; exp. al. 15 mm.

Head yellow; four black shining round spots in a transversal series between the eyes, and one on each side near the epistoma; four similar spots on the epistoma forming a quadrangle; one black line between the antennæ; two black spots on the labium; antennæ (incomplete) yellow, basal joint larger on each side with a black stripe; second joint small, faintly annulated with black; vertex globose with two transversal series of six black spots; palpi short, thick, blackish, last joint pointed; last joint of labial palpi thicker ending in a long thin thread; prothorax yellow, with two longitudinal series of four black spots and some near the front border; thorax yellowish; legs pale yellow, tibiæ of front legs with two indistinct brown spots; tibiæ of hind legs, much enlarged before the apex; front wings less than three times longer than broad with elliptical apex, hyaline, with some indistinct nebulose bands in the apical half; veins pale, alternating with black elevated tubercles; two sectors; external series of gradate veins four, beginning at the pterostigma, the last two nearer to the base; besides two near to the hind margin; internal series with four, the first one opposite the fourth of the external series; a third more basal series of four begins on the base of the second sector; the marginal space larger at base, all transversals forked, the first recurrent; a darker spot at pterostigma, and some along the margins in the apical half; hind wings little shorter, same shape, hyaline veins pale, a small black spot in the centre; only two gradate; veins on both wings pilose; abdomen long, narrow, brown, extreme apex black.

Hab. Chili, presented by C. A. Dohrn; the only specimen is perhaps a female.

2. Hemerobius psychodoides.

Megalomus psychodoides Gay, Chili, VI, p. 127, no. 4.

M. fuscescens; capite levi, fusco, nitido; antennis testaceis; alis anticis hyalinis, fusco-marmoratis, nervulis marginibusque dense fuscopunctatis; punctis omnino fere æqualibus; alis posticis hyalinis iridescentibus; pedibus pallide testaceis. Long. 1½ lin.; exp. al. 5 lin.

Hab. Chili, Cordilleras de Elqui.

3. Hemerobius marmoratipennis.

Megalomus marmoratipennis Gay, Chili, VI, p. 127, no. 5.

M. fuscescens, capite levi, satnitido; antennis fusco-testaceis; alis testaceis ovatis, hyalinis, pallide fusco-marmoratis, nervulis concoloribus, haud punctatis; alis posticis hyalinis, vix coloratis; pedibus pallide testaceis. Long. 1½ lin; exp. al. 4 lin.

Hab. Chili.

Both species are different from H. signatus, though probably of the same genus, and not belonging to Megalomus.

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